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ASSESSING SUMMER AND FALL CHINOOK SALMON RESTORATION IN THE UPPER CLEARWATER RIVER AND PRINCIPAL TRIBUTARIES

Annual Report 1994

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ASSESSING SUMMER AND FALL CHINOOK SALMON RESTORATION IN THE UPPER CLEARWATER RIVER AND PRINCIPAL TRIBUTARIES

ANNUAL REPORT 1994

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TABLE OF CONTENTS

page

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This is the first annual report of a five year study to assess summer and fall chinook salmon restoration potential in the upper Clearwater River and principal tributaries, Salmon, Grande Ronde, and Imnaha Rivers. During 1994, we focused primarily on assessing water temperatures and spawning habitat in the upper Clearwater River and principal tributaries. Water temperature analysis indicated a colder temperature regime in the upper Clear-water River above the North Fork Clearwater River confluence during the winter as compared to the lower Clear-water. This was due to warm water releases from Dworshak Reservoir on the North Fork moderating temperatures in the lower Clearwater River. Thermal temperature unit analysis and available literature suggest a 75% survival threshold level may be anticipated for chinook salmon egg incubation if spawning would occur by November 1 in the upper Clear-water River. Warm water upwelling in historic summer and fall chinook spawning areas may result in increased incubation survivals and will be tested in the future.

We observed a total of 37 fall chinook salmon redds in the Clear-water River subbasin. We observed 30 redds in the mainstem Clearwater below the North Fork Clearwater River confluence and seven redds in the North Fork Clearwater River. No redds were observed in the South Fork Clearwater, Middle Fork Clear-water, or Selway Rivers. We observed one fall chinook salmon redd in the Salmon River. We recovered 10 fall chinook salmon carcasses in the Clear-water River to obtain biological measurements and to document hatchery contribution to spawning.

In cooperation with the U.S. Fish and Wildlife Service, we PIT tagged 696 naturally produced chinook salmon subyearlings in the lower Clear-water River. A total of two (0.3 %) PIT tagged fish were detected at the mainstem dams as subyearling outmigrants compared to 22 (3.2%) detected as yearling outmigrants the following spring. Similarly, PIT tag data (N=368) on the Clear-water River during 1993 showed a lower percentage of subyearling outmigrants (6.3 %) as compared to yearling outmigrants (12.8%). Unseasonably high and cold Dworshak Dam releases coinciding with early juvenile fall chinook salmon rearing in the lower Clearwater River may be influencing selective life history traits including growth, smolt development, outmigration timing, behavior, and could be directly affecting survival, During July 1994, discharges from Dworshak Dam increased from a baseline release of 1,300 cfs to a maximum release of 25,530 cfs with an overall temperature depression in the lower Clear-water River exceeding 10 ^{0}C. With continued Dworshak Dam operations as those documented in 1994, there is potential risk to the continued existence of the endangered fall chinook salmon in the Clear-water River. Additional data and conclusions will be contained in successive years' annual reports.

INTRODUCTION

The Nez Perce Tribal Executive Committee authorized this research, which was funded by the Bonneville Power Administration (BPA). In relation to the Northwest Power Planning Council's 1994 Columbia River Basin Fish and Wildlife Program, measure 7.5B called on Fishery Managers "as quickly as possible, to develop an experimental design for implementing, monitoring and evaluating supplementation of and, if appropriate, a captive broodstock program for, Snake River fall chinook" ***Oncorhynchus tshawytscha.*** This 1994 annual report is for the first year of a five year study to assess summer and fall chinook salmon restoration or enhancement potential through supplementation in the upper Clearwater River and mainstem tributaries, lower Salmon, Grande Ronde, and Imnaha rivers.

We are studying summer and fall chinook salmon restoration or enhancement potential because these stocks were historically present in most major tributaries of the Snake River and are currently extinct or on the brink of extinction. The Snake River spring/summer and fall chinook stocks were listed as threatened in 1992 under the Endangered Species Act (ESA) and reclassified as endangered in 1994. Historically, all salmon stocks in the Snake River Subbasin were important to the Nez Perce Tribe in terms of food resources and cultural values and still are today.

The first two years of study (1994-95) address current summer and fall chinook salmon use and spawning habitat evaluations in the upper Clearwater River (above the North Fork Clearwater River confluence) and major tributaries. Previous work addressed fall chinook spawning timing, incubation and juvenile rearing in the lower Clear-water River (below the North Fork) where most fall chinook spawning has been documented since spawning surveys began in 1988 (Arnsberg et al. 1992). We believe limiting factors for successful restoration of summer and fall chinook salmon in the upper Clear-water and tributaries may be cold water temperatures during the early egg incubation period and warm temperatures during summer juvenile rearing. Other factors that may limit restoration success may be spawning substrate quality and, in some colder years, ice scouring effects on the spawning substrate and incubating eggs. However, outmigration timing and survival of fall chinook salmon juveniles to the ocean, as with all anadromous species, may be the most prominent single factor limiting recovery and restoration of ESA listed stocks.

We include in this report a supplementation experimental study design to investigate the survival of Lyons Ferry Hatchery fall chinook salmon (Snake River stock) to Lower Granite Dam following releases in the lower Clearwater River. Supplementation of Lyons Ferry Hatchery fall chinook has never occurred in the Snake River subbasin above Lower Granite Dam. Adequate juvenile survival for successful restoration of the Snake River fall chinook was a critical uncertainty identified in the lower Clear-water River Study (Arnsberg et al. 1992). Arnsberg et al. (1992) recommended Lyons Ferry Hatchery fall chinook releases in the lower Clearwater River to evaluate survival to the mainstem dams and to assess adult returns to the spawning areas.

Our objectives for 1994 were to determine optimal spawning times for successful chinook salmon egg survival based on water temperatures in the upper Clearwater River subbasin. We monitored water temperatures during the summer to assess chinook salmon rearing conditions. We began to quantitatively and qualitatively evaluate potential chinook salmon spawning habitat in the upper Clear-water River and mainstem tributaries and final results will be in our 1995 annual report. In cooperation with the U.S. Fish and Wildlife Service (USFWS), we investigated the movement patterns, growth rates, and relative survival of naturally produced (wild) subyearling chinook salmon in the lower Clearwater River to Lower Granite Dam through the use of passive integrated transponder (PIT) tags. As mentioned previously, we planned to investigate the movement patterns, growth rates and survival of supplemented Lyons Ferry Hatchery fall chinook released in the Clearwater River to Lower Granite Dam, however, adult returns to the hatchery in 1994 were low and fish were unavailable. We will conduct juvenile survival studies in successive years if enough hatchery fall chinook are available. During 1995, we will measure the effects of ice flow and scour on potential spawning substrate in the upper Clear-water River and mainstem tributaries. Our 1995 annual report will also include a chinook salmon broodstock management plan for the Clear-water River subbasin. Research results from the Salmon, Grande Ronde, and Imnaha Rivers will be contained in future annual reports.

PROJECT AREA DESCRIPTION

Our study area includes 55 km of the mainstem Clear-water River (above the North Fork Clear-water River confluence) and its principal tributaries including the Middle Fork Clearwater River (37 km), the lower 21 km of the South Fork Clearwater River, the lower 39 km of the Lochsa River, and the lower 37 km of the Selway River (Figure 1). During 1996-98, our study area will also include the lower sections of the Salmon, Grande Ronde, and Imnaha Rives (Figure 1). We continued conducting fall chinook aerial redd surveys on the Salmon River during 1994 and results are included in this report.

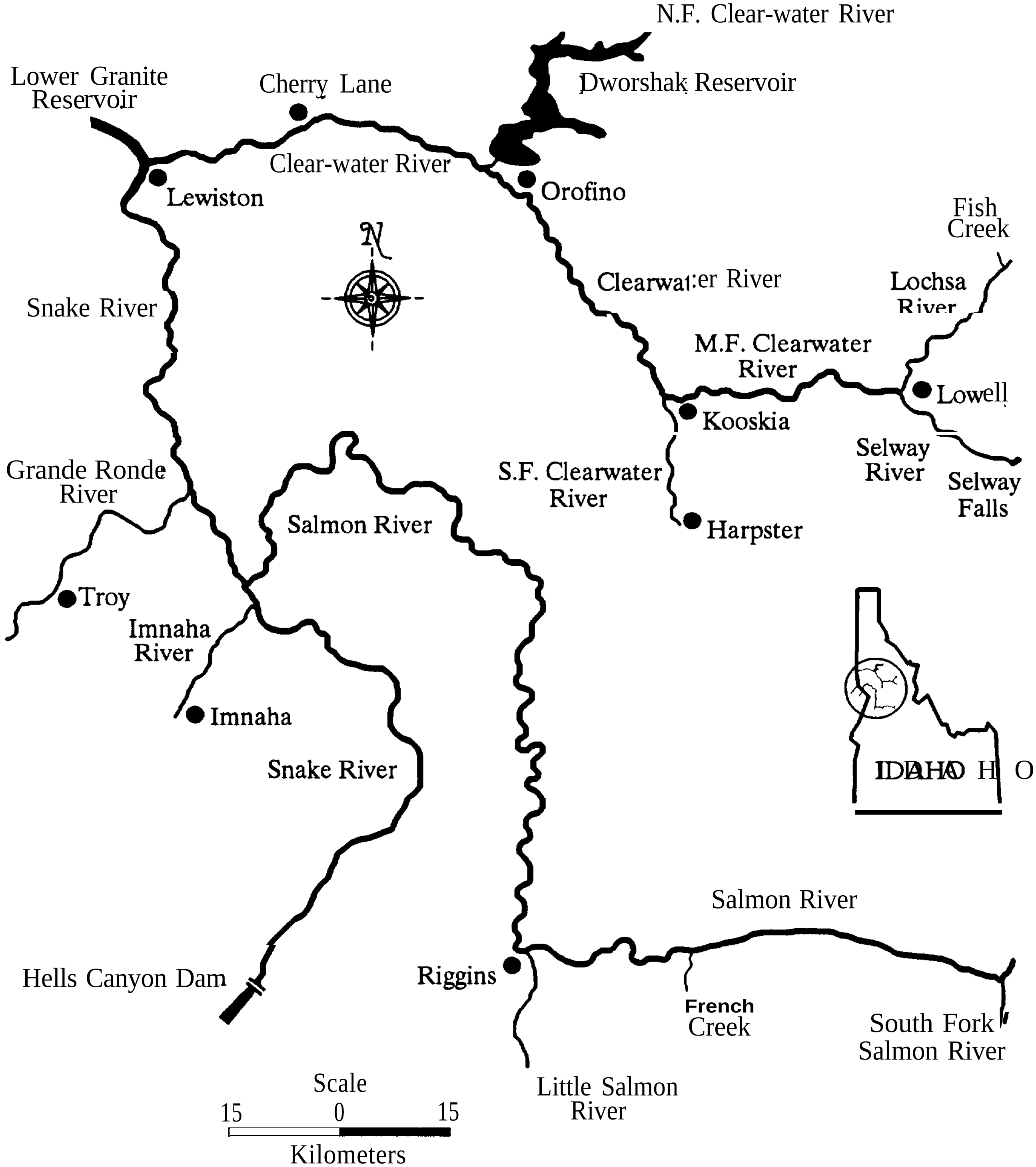

Figure 1. Nez Perce Tribe study streams for summer and fall chinook salmon restoration that includes the Clearwater, Middle Fork Clearwater, South Fork Clearwater, Lochsa, Selway, Salmon, Grande Ronde, and Imnaha Rivers.

METHODS

Temperature Analvsis

We used Ryan TempMentors and Onset temperature loggers to record hourly water temperatures in the Clear-water River at Cherry Lane and at Orofino above the confluence of the North Fork Cleat-water River and on the Selway River just below Selway Falls (see Figure 1). We evaluated maximum, minimum, and daily average temperatures to assess summer rearing conditions for chinook salmon as compared to thermal tolerances reported in the literature.

Accrued thermal temperature units (TU's) (Piper et al. 1989) were calculated representing an October spawning summer chinook and a November spawning fall chinook. These data were then used to help identify anticipated egg survival during the early incubation period. Limited data exist on the relationship between temperature and early egg incubation survival for chinook salmon. Beacham and Murray (1987) reported survival levels at various temperatures for pink salmon Oncorhynchus ***gorbuscha.*** These relationships were applied to temperatures collected in the Clearwater River since they should be similar for chinook salmon eggs (Cramer 1995).

We predicted emergence timing for October and November spawning chinook salmon in the upper Clear-water River at Orofino and on the Selway River. We used a 900 ^{0}C thermal TU requirement from fertilized egg to emergence for summer chinook (Arnsberg et al. 1992) to predict emergence timing in the upper Clear-water River subbasin.

Spawning Habitat Abundance

We located potential chinook salmon spawning areas in the upper Clear-water River study streams by applying substrate criteria as described in Amsberg et al. (1992). Spawning areas with dominant substrate particles of medium gravels to small cobbles (25 to 152 mm) and subdominant particles < 228 mm were selected as suitable for summer and fall chinook salmon spawning. Potential spawning areas were mapped to facilitate future location and to obtain spawning area measurements during 1995.

Spawning Habitat Oualitv

We used the freeze core technique (Everest et al. 1980) with modifications as described by Amsberg et al. (1992) to obtain substrate samples at potential chinook salmon spawning locations identified on the South Fork Clearwater and the Selway Rivers. We experimented with a modification of the tri-tube freeze core sampler used by Arnsberg et al. (1992) so that each tube of the sampler received liquid CO, simultaneously instead of in series (i.e. one probe at a time). This modification was tested to reduce the sampling time from an average of 44 minutes per sample (Arnsberg et al. 1992) to about l0-15 minutes per sample. After a number of tests at different CO, injection rates and pressures, simultaneous injection was abandoned due to insufficient freezing of the core samples. We speculated that the individual probe spacing of 15.2 cm, twice that as used by Everest et al, (1980), limited freezing of substrate particles to immediately around each probe. The central portion of the sample was not thoroughly frozen and was lost during extraction. We believe time is probably a key factor for obtaining a large, solidly frozen core sample, much like the formation of an ice cube in a freezer. The slower CO_2 injection rate allows solid freezing to occur.

Aerial Spawning Survevs

We conducted aerial redd surveys by helicopter approximately weekly from October 25 to December 1 along the entire mainstem Clear-water River, North Fork Clearwater River from the mouth to Dworshak Dam, Middle Fork Clearwater River, South Fork Clearwater River from the mouth to the town of Harpster, and on the Selway River from the mouth to Selway Falls (see Figure 1). Through cooperation and assistance from the Bureau of Land Management in Cottonwood, Idaho, we conducted aerial redd surveys on the Salmon River from the mouth of the South Fork Salmon River to its confluence with the Snake River (see Figure 1). We documented the timing, number, and distribution of fall chinook salmon redds. We collected fall chinook salmon carcasses seen from the air the same or following day to obtain measurements of fork length, post orbital to hypural plate length, sex composition, percent egg retention, and to determine any identifying marks indicating hatchery fish. Scales were collected from all fall chinook salmon carcasses and sent to the Columbia River Inter-Tribal Fish Commission for age determination (Jerald 1983).

We conducted redd surveys from mid-morning to mid-day for the best lighting conditions. Fall chinook salmon redds, live fish, and carcasses seen from the air were mapped on aerial photographs, however, only general locations are presented in this report. We recorded weather conditions on all redd surveys and measured water transparency using a standard secchi disk for the Clearwater River below the North Fork Clearwater River confluence where adequate mixing had occurred. Water discharges during redd surveys were obtained from the United States Geological Survey (USGS) gauging stations for the Clear-water River at Spalding and the Salmon River at Whitebird.

Juvenile Chinook Salmon Survival and Movement Patterns

We developed an experimental study design to evaluate supplementation of Lyons Ferry Hatchery fall chinook salmon into the lower Clearwater River beginning the spring/summer 1995 (Appendix A). Our study design incorporates the Survival Under Proportional Hazards (SURPH) model developed by the University of Washington (Smith et al. 1994) to estimate juvenile survival to Lower Granite Dam. However, we were unable to obtain subyearlings for evaluation in 1995 due to the low number of adult returns to Lyons Ferry Hatchery in 1994 and the Production Advisory Committee's (PAC) recommendation to release all Lyons Ferry Hatchery fall chinook at the hatchery to maximize survival.

In cooperation with the USFWS Idaho Fishery Resource Office (IFRO), we captured and PIT tagged wild chinook salmon in the lower Clearwater River. We targeted fall chinook subyearlings by concentrating our seining efforts below fall chinook redds located the previous fall. We calculated thermal TU's to predict emergence timing and to estimate growth to 60 mm fork length, the minimum size for PIT tagging. Seining methods and PIT tagging protocols used are described by Connor et al. (1994). We obtained PIT tag detection data from the PIT Tag Information System (PTAGIS) to obtain outmigration data at the mainstem Snake and Columbia River dams. We compared chinook salmon PIT tag data to the 1993 PIT tag data on the Clearwater River and to PIT tag data collected by the IFRO on the Snake River from 1991-1994.

RESULTS AND DISCUSSION

Temperature Analysis

Water temperatures were generally a few degrees colder throughout the year in the Selway River as compared to the Clear-water River (Figure 2, Appendix B). An exception was during July in the Clear-water River at Cherry Lane where unseasonably higher cold water discharges from Dworshak Reservoir dominated temperatures from the upper Clearwater River (Figure 2) . During the end of November through February, temperatures in the Selway River and Clear-water River at Orofino fluctuated between 0 and 3 ^{0}C. The warming effects of Dworshak Reservoir water releases kept temperatures approximately 2 ^{0}C warmer in the Clearwater at Cherry Lane during the same period. The highest average daily water temperature of 26.5 ^{0}C was recorded in the Clearwater River at Orofino around the first of August (Figure 2) . This was slightly higher than the tolerable limit of 25.1 ^{0}C reported by Brett (1952) and 25.0 ^{0}C reported by Bell (1984) for chinook salmon. To avoid these brief periods of high temperatures in the upper Clearwater River, chinook juveniles would either have to seek refuge in cooler, deep pools or spring areas or migrate to the lower river or to the ocean as subyearlings. Temperatures in the Selway River and the lower Clear-water River at Cherry Lane remained below the tolerable limit of 25 ^{0}C (Figure 2).

Cramer (1995) suggested that survival of chinook salmon eggs is dependent upon sufficient thermal TU's achieved to the eyed egg stage of development prior to water temperatures declining below 4 ^{0}C. Cramer's conclusion was based upon an egg survival study for pink salmon by Beacham and Murray (1987). They reported a 75% survival for eggs transferred from 8 to 2 ^{0}C water at the epiboly stage (136 TU's) of development . Eggs transferred at the early eyeing phase (19 TU's) achieved a 95 % survival. Cramer (1995) suggested these tolerances should be similar for chinook salmon eggs. If this is true, chinook salmon would have to spawn before the third week in October in the Clear-water River above the North Fork confluence to achieve maximum egg survival (Figure 3), unless adults seek out and select warm water upwelling areas for spawning. Based on Beacham and Murray's (1987) study, a 75 % egg survival would be expected for fall chinook salmon that would spawn around November 1 and lower survivals would be predicted for later spawning times (Figure 3). We plan on testing the survival thresholds reported by Beacham and Murray on fall chinook eggs placed in the upper Clear-water River during 1996.

Anticipated fall chinook egg survival may be lower for the Selway River where water temperatures reach 4 ^{0}C earlier than the Clearwater River at Orofino. Based in part on egg survival criteria and above substrate water temperatures, Cramer (1995) recommended an October spawning summer chinook (upper Columbia River stock) with a subyearling outmigrant life history characteristic for restoration into the Selway River. However, Cramer qualified his recommendation by indicating ***"it, is probable that fall chinook historically spawned in restricted areas of the basin where warmer than average water upwells through the gravel. It is common for salmon to spawn in groundwater or spring areas where water temperatures difer from that in the stream. The eyewitness accounts of***

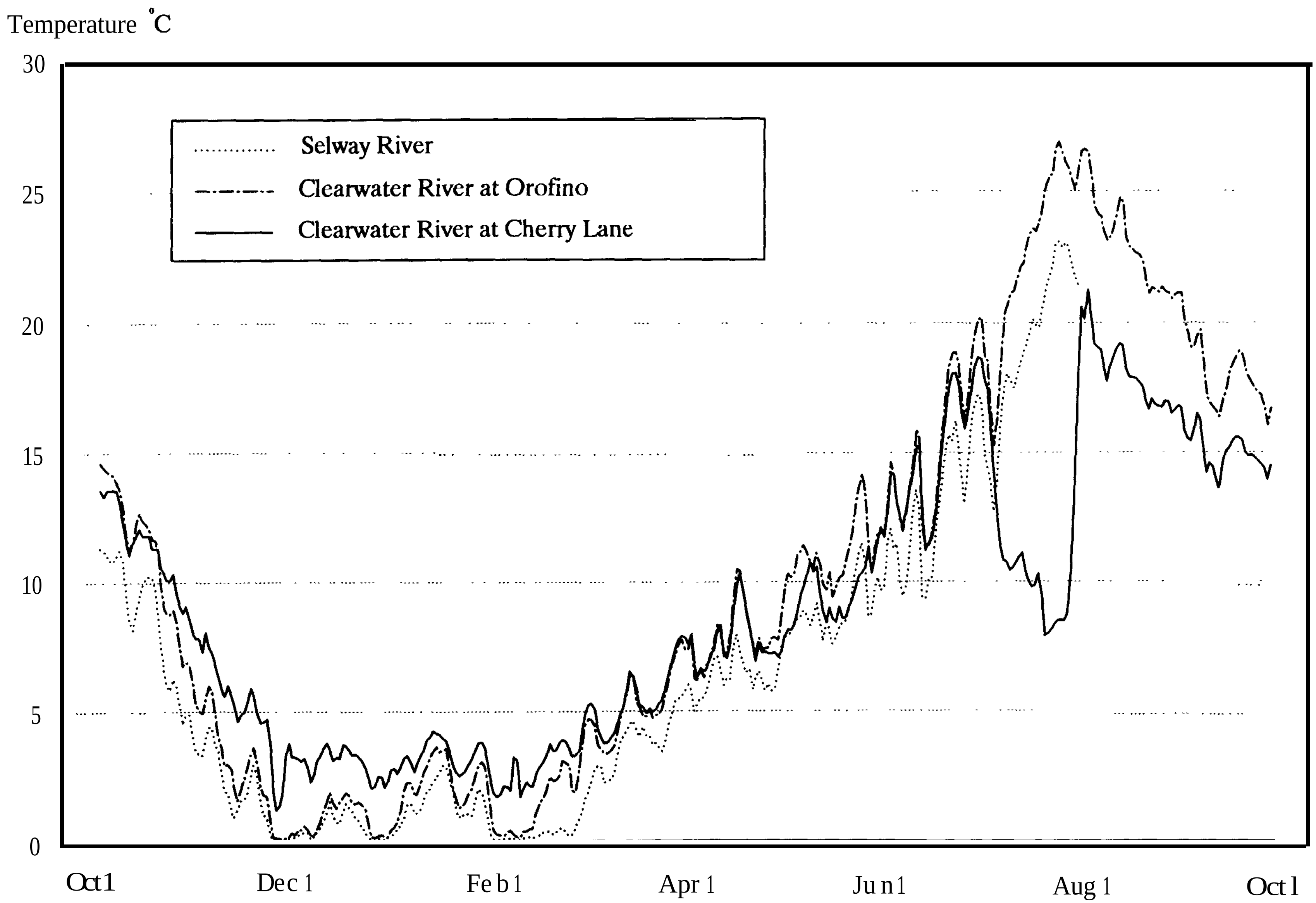

Figure 2. Average daily water temperatures in the Clearwater River subbasin during 1993-1994.

fall chinook in the Selway River during the early 1900's indicates that such groundwater areas exist within the Selway Basin." Preliminary water temperature data from 1993-1994 suggest that an early to mid-October spawning summer chinook would be successful in the lower Selway River . This will be evaluated further from successive years of data collection.

Due to the potential significance of warm water upwelling areas to fish stock suitability, we plan to search and map these areas in successive years. Thermal upwelling areas will be located by flying the river during winter and locating ice-free areas. The application of infrared technology to identify upwelling areas will also be investigated. After thermal areas are located, we will place thermographs in the spawning substrate to measure temperature differences from the water column.

Emergence timing of an October 1 spawning summer chinook salmon would be around April 26 on the Clear-water River at Orofino and around May 26 on the lower Selway River (Figure 4). Emergence timing for a November 1 fall chinook salmon would be around May 28 on the Clear-water and around June 19 on the lower Selway River. This is late in the year for chinook salmon fry emergence, especially for a Snake River fall chinook which typically outmigrates to the ocean as a subyearling Subyearlings may not obtain a large enough size for smoltification during the first year of life and may not smolt until the following spring. However, a yearling outmigration may be advantageous and provide a better smolt-to-adult return ratio given the current inhospitable migration conditions created by th mainstem dams and reservoirs during the summer During the late summer, flows in th mainstem Snake and Columbia Rivers are low, fall chinook are not guided as easily and go through the turbines, predation is higher, and water temperatures typically exceed 20 ^{0}C. Yearling chinook salmon from the Clearwater River migrate primarily in April and are benefited by higher spring flows, fish bypass facilities at the dams, lower predation, and much lower water temperatures .A later emergence time would be predicted for later spawning chinook salmon (Figure 4). However, if fish would spawn in thermal upwelling areas, earlier emergence would be predicted and a subyearling outmigration may be attainable.

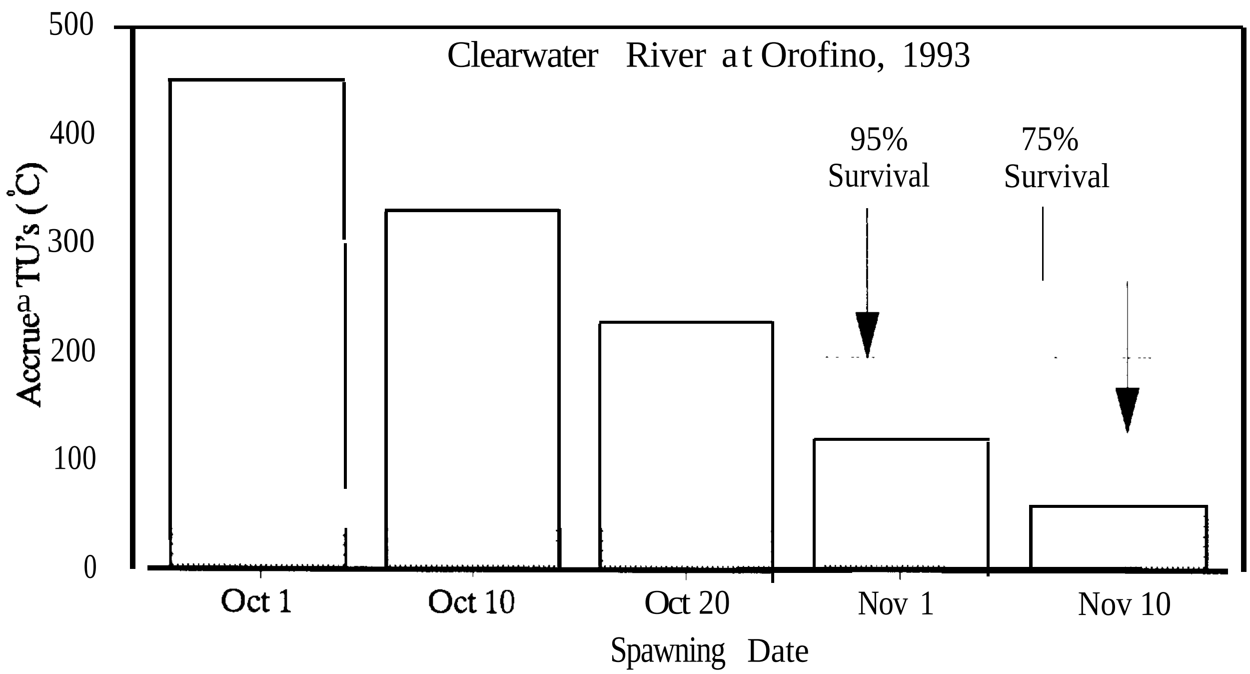

Figure 3 . Post spawning temperature unit accrual prior to mean daily water temperatures declining to 4°C in the Clear-wate River at Orofino, 1993 and 95% and 75% survival thresholds measured for pink salmon early development as reported b Beachyam and Murray (1987).

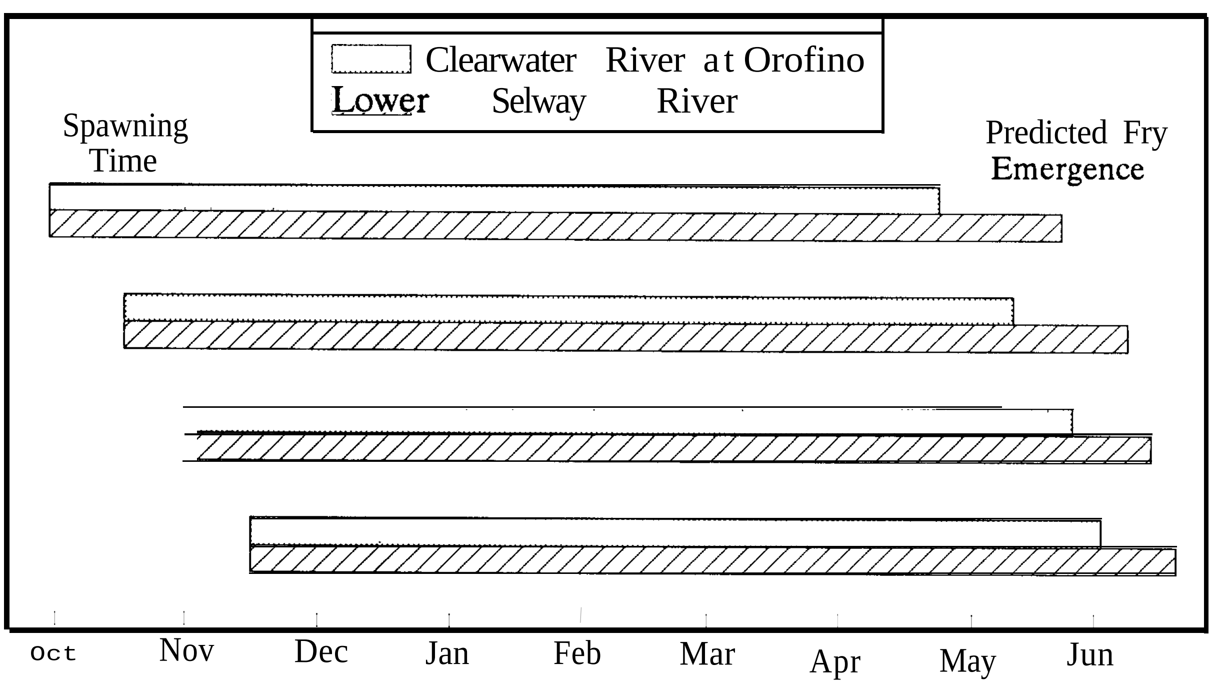

Figure 4. Predicted emergence timing for chinook salmon that would spawn in the Clearwater River at Orofino or in the lower Selway River on the date given during 1993.

Spawning Habitat Abundance

Spawning habitat abundance measurements in the upper Clearwater River drainage are ongoing and results will be reported in our 1995 annual report.

Spawning Habitat Quality

We collected 10 freeze core samples in each the South Fork Clearwater and Selway Rivers. Additional substrate samples will be obtained during 1995 on the Middle Fork Clear-water and Lochsa Rivers. All substrate quality work will be contained in our 1995 annual report. We will also measure the extent and depth of ice scouring in the upper Clearwater River study streams by placing markers at different depths within the spawning substrate. Ice scour may be a limiting factor for chinook salmon egg survival. Ice scouring results will also be contained in our 1995 annual report.

Aerial Spawning Survevs

We observed a total of 37 fall chinook redds in the Clearwater River subbasin during 1994. We observed 30 redds in the lower Clear-water River from the mouth to the North Fork Clear-water River confluence and 7 redds in the North Fork Clear-water River adjacent to the Dworshak National Fish Hatchery (DNFH) fish ladder (Table 1). There were no fall chinook salmon redds observed during 1994 on the mainstem Clearwater above the North Fork, or on the South Fork Cleat-water, Middle Fork Clearwater, or Selway Rivers. Several spawning chinook were observed on redds in the Clear-water and North Fork Clear-water Rivers. We observed one fall chinook redd with a spawning pair on the Salmon River near the town of Riggins immediately upstream of the Little Salmon River confluence (Table 2).

Observation conditions were good during spawning surveys. Weather ranged from sunny to mostly high clouds with good lighting conditions on all surveys. Discharges were fairly uniform and ranged from 2,980 to 3,521 cfs on the Clear-water River with a stable discharge of approximately 1,200 cfs from Dworshak Dam into the North Fork Clear-water (Table 1). The Salmon River discharges ranged from 3,130 to 3,600 cfs (Table 2). Water transparency on the Clearwater River ranged from 3.4 to 4.9 m (Table 1). We did not measure water transparency on other rivers surveyed, however, estimated it to be good to excellent (3-4 m) on all surveys.

We recovered 10 out of 15 fall chinook carcasses observed during aerial redd surveys on the Clearwater River (Table 3) Carcasses were recovered within a day of observation. Eight of the 10 fall chinook collected were females. Six females had 5% or less egg retention and two fish retained approximately 50 and 70 % of their eggs (Table 3) None of the carcasses were from pre-spawning mortalities.

Table 1. Fall chinook salmon aerial redd survey dates, number of new redds observed by date, location, and water conditions on th mainste m Clear-water River, Idaho, 1994.

Survey Date	No. new redds	Redd Location	River Km	Q (cfs)	Transparency (m)
10/25	3	Cherry Lane (Fir Island)	35	2,980	4.5
	1	Approx. 2 Km upstream of Peck	59		
	2	Islands below Ahsahka	64		
Total	6				
11/8	10	Cherry Lane (Fir Island)	35	3,521	4.0
	2	N.F. Cleat-water, at DNFH ladder	0.5	1,300	good
Total	12				
11/18	4	Hog Island (main channel)	13	3,280	4.9
	5	Cherry Lane (Fir Island)	35		
	2	Islands below Ahsahka	64		
	4	N.F. Clear-water, at DNFH ladder	0.5	1,300	good
Total	15				
11/22	0	Clear-water River		3,180	3.4
12/1	2	Hog Island (main channel)	13	3,200	4.0
	1	Island below Lenore Bridge	46		
	1	N.F. Clearwater, at DNFH ladder	0.5	1,000	good
Total	4				
Grand Total	37				

a Discharge obtained from the USGS gauging station at Spalding for the Clearwater River and from Dworshak Dam Operations for the North Fork Clear-water River.

Table 2. Fall chinook salmon aerial redd survey dates, number of new redds observed by date, location, and other survey data on the lower Salmon River, Idaho, 1994.

Survey Date	No. new redds	Redd Location	River Km	Q (cfs)	Transparency
l0/25	0			3,130	excellent
1l/8	1	Approx. 0.1 km upstream of the Little Salmon confluence	140.1	3,600	excellent
12/l	0			3,430	good
Total	1				

a Discharge obtained from the USGS gauging station at Whitebird.

Table 3. Fall chinook salmon carcass data from the Clearwater River, Idaho, 1994.

Date	Rkm	Fork lth (cm)	Post-orb. hypural lth (cm)	Sex	Age”	Identifying characteristics	% eggs retention
l0/26	62	93	78	M	4/l	None	0
11/22	33	81	65	F	?	Rt ventral fin clip, snout taken for CWT determination”	0
11/22	34	83	66	F	4/l	None	50
11/23	0.1	88	76	F[b]	4/l	None	0
12/2	31	92	71	M	?	Rt ventral fin clip, snout taken for CWT determination”	0
12/2	33	78	66	F	3/l - 4/l ?	Adipose clip, snout taken for CWT determination[d]	10
12/2	33	89	76	F	4/l	None	70
12/2	33	92	77	F	5/l	None	5
12/2	33	66	54	F	3/l	None	10
12/2	33	79	65	F	?	None	5

a Age determined from scale analysis by the Columbia River Inter-Tribal Fish Commission. Age is adult age at return and age of ocean entry (e.g. 4/l denotes a 4 year old adult return that entered the ocean as a subyearling or during its first year of life).

b Collected on the North Fork Clearwater River 0.1 km above its mouth.

c No coded wire tag found.

d Coded wire tag # 75449; smolt release in the Umatilla River on 5/10/91.

Scale analysis from fall chinook carcasses revealed that seven out of 10 fish collected entered the ocean during their first year of life or as subyearlings (Table 3). The year of ocean entry for three fish could not be determined from scale analysis because of poor scale condition. Two fall chinook had a right ventral fin clip but no coded wire tags were found in their snouts. Right ventral clipped fall chinook with no tags signifies strays from the Umatilla River (Glen Mendel, WDFW, personal communication). One fish had an adipose fin clip along with a coded wire tag in its snout. According to the coded wire tag database, this fish was released as a smolt in the Umatilla River from the Umatilla Hatchery in May, 1991 (Table 3).

There were three fall chinook salmon that entered the fish ladder at DNFH in 1994 (USFWS, unpublished data). An 86 cm fork length (FL) female was observed in the hatchery holding pond on November 18 and released into the Clearwater River just above the North Fork Clearwater River confluence on November 22. A 53 cm FL male was observed in the hatchery on December 7 and released the same day. A 66 cm FL female was observed dead on 12/ 14 in the holding pond. DNFH has never produced or released fall chinook salmon at the facility, but fall chinook do naturally spawn in the North Fork Clearwater River. It is not unexpected for fall chinook spawned in the North Fork Clearwater River to follow the hatchery attraction flows comprised of North Fork water.

Juvenile Chinook Salmon Survival and Movement Patterns

We include an experimental study design to evaluate supplementation of the Clearwater River fall chinook salmon population by using Lyons Ferry Hatchery fall chinook (Appendix A). Basic principles in this design will be used to evaluate future supplementation of fall chinook salmon from Lyons Ferry Hatchery in all study streams above Lower Granite Dam.

In cooperation with the USFWS, we PIT tagged a total of 696 naturally produced chinook salmon in the lower Clearwater River during 1994 (Figure 5). Chinook salmon captured on the Clear-water River were not large enough for PIT tagging until June. The peak number tagged was near the end of June at an average size of 73 mm (Figure 5). No chinook juveniles were captured in seine hauls after the second week of July, coinciding with increased cold water discharges from Dworshak Reservoir (Figure 8).

Chinook salmon PIT tagged by the USFWS on the Snake River during 1994 were 2-3 weeks ahead in growth than the Clearwater River fish (Figure 5). Chinook subyearlings averaged 82 mm the week of June 15 on the Snake River and fish did not attain that size on the Clear-water River until the second week of July. Similar chinook salmon size differences can be seen between the Clearwater and Snake rivers from the 1993 PIT tagging data (Figure 6). Similar to 1994, subyearlings PIT tagged on the Cleat-water River averaged 73 mm around July 1. Fall chinook spawning in the Clearwater and Snake Rivers takes place from the end of October through November. Size differences between the Clearwater and Snake River fall chinook can be attributed primarily to warmer water temperatures in the Snake during the early egg incubation period (Arnsberg et al. 1992).

A total of two (0.29%) chinook salmon from the 1994 PIT tag sample (n=696) on the Clearwater River were detected as subyearling migrants at the mainstem dams during 1994 (Figure 7). One fish was detected on August 18 and the other on September 27. In comparison, there was a 10.7% detection rate for subyearling outmigrants in the Snake River during 1994 (n=2,342). Yearling detections rates were 3.2% and 3.5% for the 1994 Clearwater and Snake PIT tagged fish, respectively. Data for the 1993 PIT tagged group (n =368) on the Clearwater resulted in a 6.3 % detection of subyearlings at the mainstem dams compared to a 12.8% detection of yearling outmigrants. In comparison to the Snake River PIT tag data during 1993, there was a 22.8% detection on subyearling outmigrants and a 4.4% detection of yearling outmigrants. Comparing four consecutive years of PIT tag data collected on the Snake River by the USFWS, it is evident there is a wide variation in percent detections at the dams from year to year (Figure 7).

Of the 47 yearling outmigrants detected in 1994 from the 1993 PIT tagged group on the Clear-water River, 29 (62%) were first detected at Lower Monumental Dam and most fish were detected in April. These fish may have overwintered in Lower Monumental pool since they were not detected earlier that spring at Lower Granite or Little Goose dams. The mainstem dam by-pass facilities and PIT tag detectors are typically not in operation during the winter. Operations do not commence until around March, therefore, we do not know

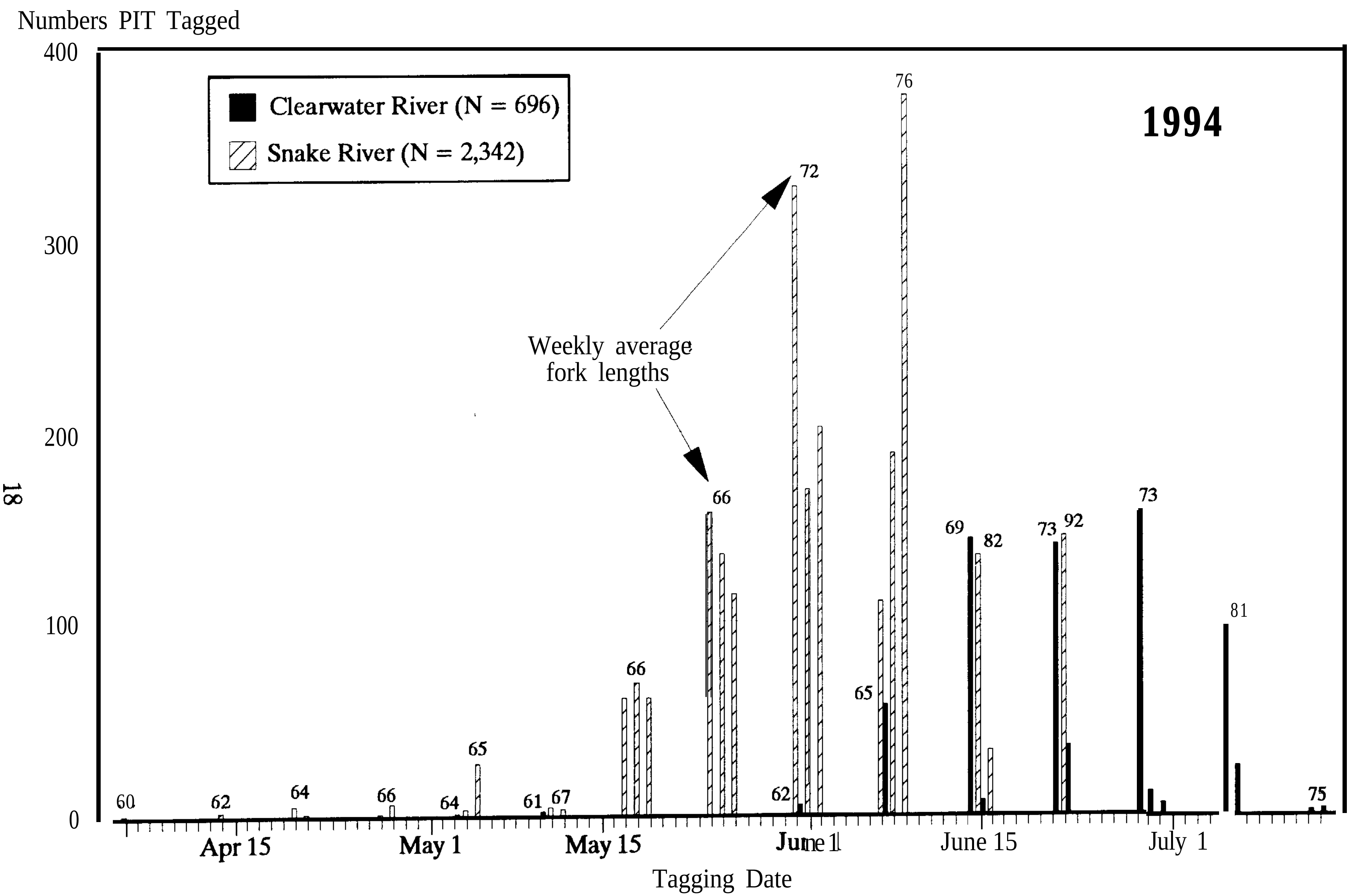

Figure 5. Total number of wild chinook salmon PIT tagged/day and weekly average fork length (mm) of PIT tagged fish on the Clearwater and Snake Rivers, Idaho, 1994.

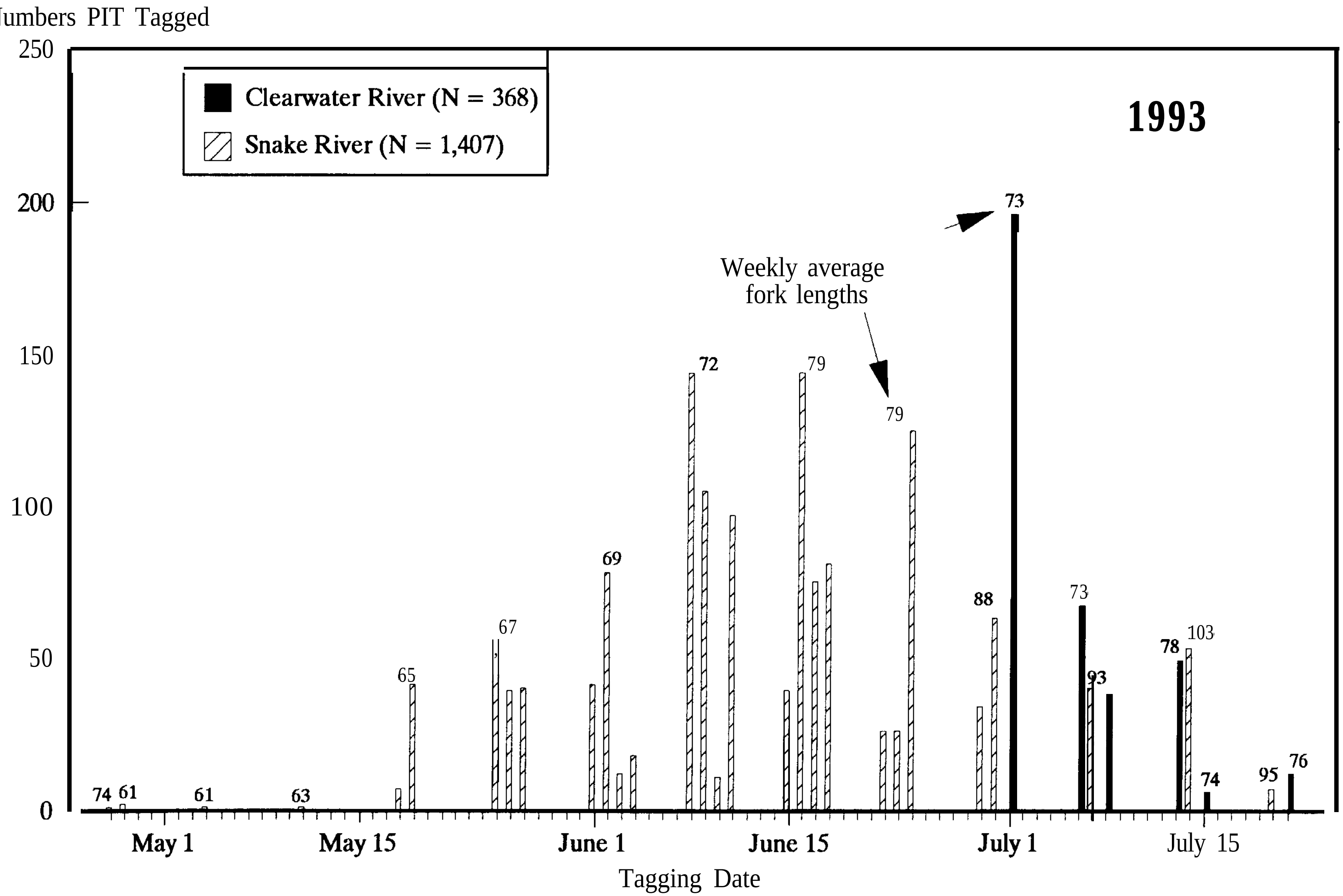

Figure 6. Total number of wild chinook salmon PIT tagged/day and weekly average fork length (mm) of PIT tagged fish on the Clearwater and Snake Rivers, Idaho, 1993.

when these yearlings migrated past Lower Granite Dam. We can conclude, however, that these fish probably passed through the turbines at Lower Granite and Little Goose dams since the by-pass facilities were not operable and spill did not occur during the winter.

It is possible that we PIT tagged a high percentage of spring chinook on the Clearwater during 1993 and 1994 which is reflected in the higher proportion of yearling outmigrants (Figure 7). Subyearling migration is the natural life history pattern for the Snake River fall chinook. We concentrated our seining efforts, however, below known fall chinook spawning redds and fish size was smaller than that of spring chinook if they were spawned in the lower Clearwater. Spring chinook fry may have outmigrated to the Clearwater River from the upper tributaries where size would be more similar to fall chinook fry in the Cleat-water. However, spring chinook have not been documented from trapping data to outmigrate as subyearlings from tributaries to the mainstem Clearwater during June and July in any appreciable numbers (Jay Hesse, Nez Perce Tribe Department of Fisheries Resources Management, Orofino, Idaho, personal communication). In the future, we plan to subsample subyearlings in the Clearwater River for genetic analysis to determine whether they are spring or fall chinook.

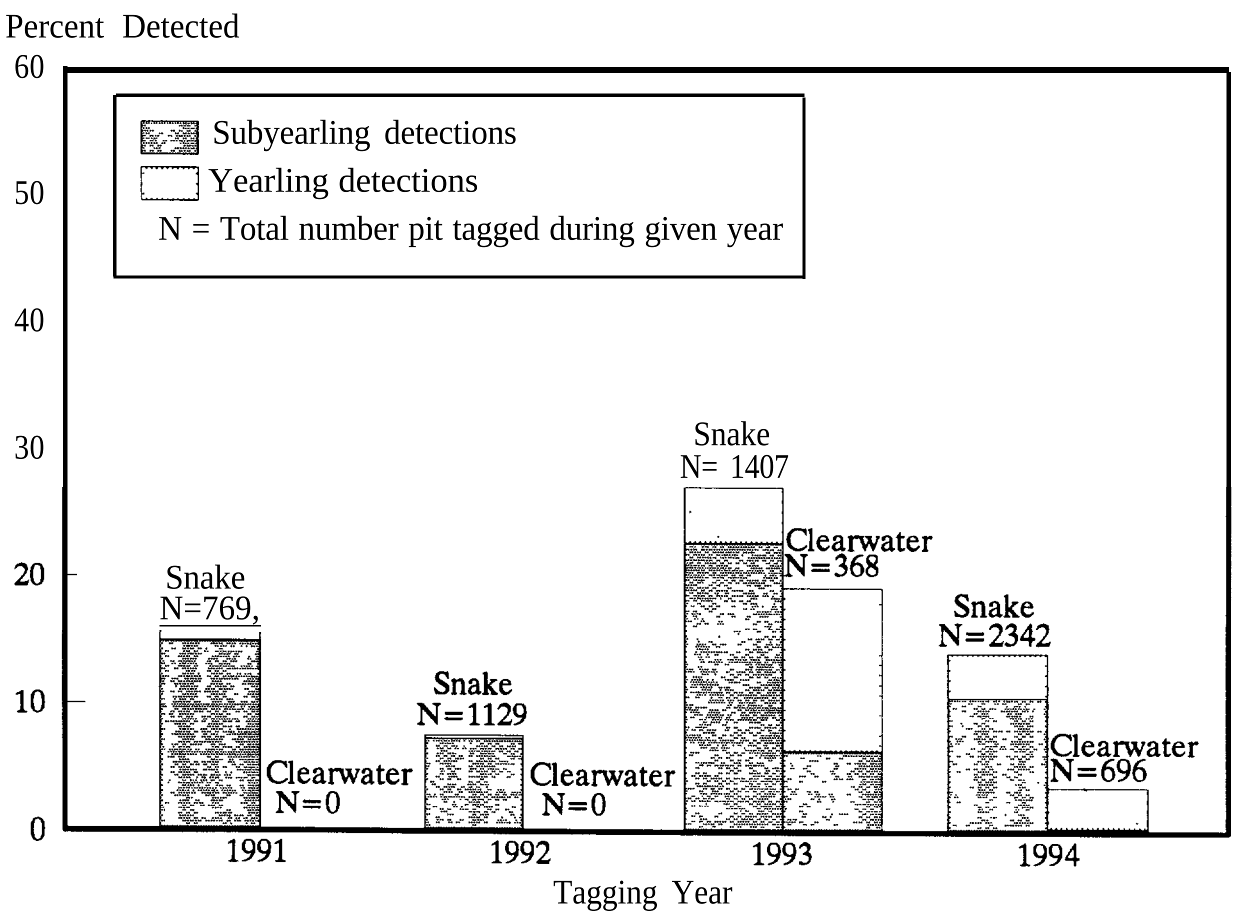

Figure 7. Mainstem dam PIT tag detections for wild subyearling chinook salmon tagged on the Snake (USFWS) and Clearwater (USFWS and Nez Perce Tribe) Rivers, Idaho.

The 1994 Cleat-water River flow regime, shaped by Dworshak Dam discharges, consisted of extended periods of abnormally high, cold water discharges interspersed with transition periods of rapid and extreme changes in discharge and temperature (Figure 8, Appendix B). Dworshak discharges oscillated between base flows of about 1,200 cfs to peak flows of 20,000-25,000 cfs through the spring and summer (Figure 8). The potential risks to fall chinook salmon as a result of this type of operational regime are discussed below.

Egg development and growth of fall chinook salmon spawned in the Cleat-water River is largely temperature dependent. The USFWS (1979) found that fall chinook salmon smolt size was similar regardless of their outmigration timing, and concluded that the fish needed to achieve a threshold size to effect smoltification. Connor et al. (1993) reported that Snake River fall chinook subyearlings smolted at an average of 127 mm from sampling at Lower Granite Dam, however, fish started actively migrating at around 80 mm. During July, 1994, when chinook salmon fry in the Clear-water River averaged 75-80 mm, Dworshak discharges increased from 1,300 cfs to 25,3 10 cfs with a water temperature release of around 7.2 ^{0}C. This resulted in Cleat-water River flows about 20 times the natural base flow conditions with an overall temperature depression exceeding 10 ^{0}C (Figure 8, Appendix B). Growth inhibition and smolt development due to decreased water temperatures could, in part, explain why more Clearwater fall chinook salmon outmigrated as yearlings rather than subyearlings.

Water temperature is more than likely the single most important factor affecting fish growth (Piper et al. 1989). Bjomn and Reiser (unpublished manuscript) also reported that unusual and unstable stream temperatures can lead to disease outbreaks in migrating fish, altered timing of migration, and accelerated or retarded maturation. Most stocks of anadromous salmonids have evolved with the temperature patterns of their natal streams, and significant abrupt deviations from the normal pattern could adversely affect their survival (Bjomn and Reiser, unpublished manuscript). Banks et al. 1971 reported that a water temperature of 15.6 ^{0}C appeared closest to the optimum for propagation of fall chinook fingerlings averaging between 1.38 and 8.94 grams. Weight gains were consistently greater at this temperature than at 10 or 12.7 ^{0}C. Performance of fall chinook fingerlings at 18.3 ^{0}C was variable, however, some test groups had slightly better gains than fish reared in 15.6 ^{0}C water (Banks et al. 1971). Chinook salmon may gain more even at temperatures around 20 ^{0}C, if food resources are not a limiting factor. Brusven and MacPhee (1976) reported that the lower Cleat-water River was very rich in aquatic insects, however, fluctuating flows from Dworshak Dam could have an effect on productivity. Amsberg et al. (1992) reported very low anadromous fish densities with an apparent abundance of food resources in the lower Cleat-water River.

Amsberg et al. (1992) recommended a total Clearwater River (at Spalding) discharge of 5,000 cfs during the summer and fall accompanied with a release of 10 ^{0}C water from Dworshak Dam (Figure 9). Amsberg et al. (1992) also recommended that the Cleat-water River discharge follow the natural hydrograph in the spring to assist in downstream migration of anadromous fish. The Cleat-water discharge pattern for 1994, dominated by Dworshak Dam flow releases, diverged significantly from these recommendations (Figure 8).

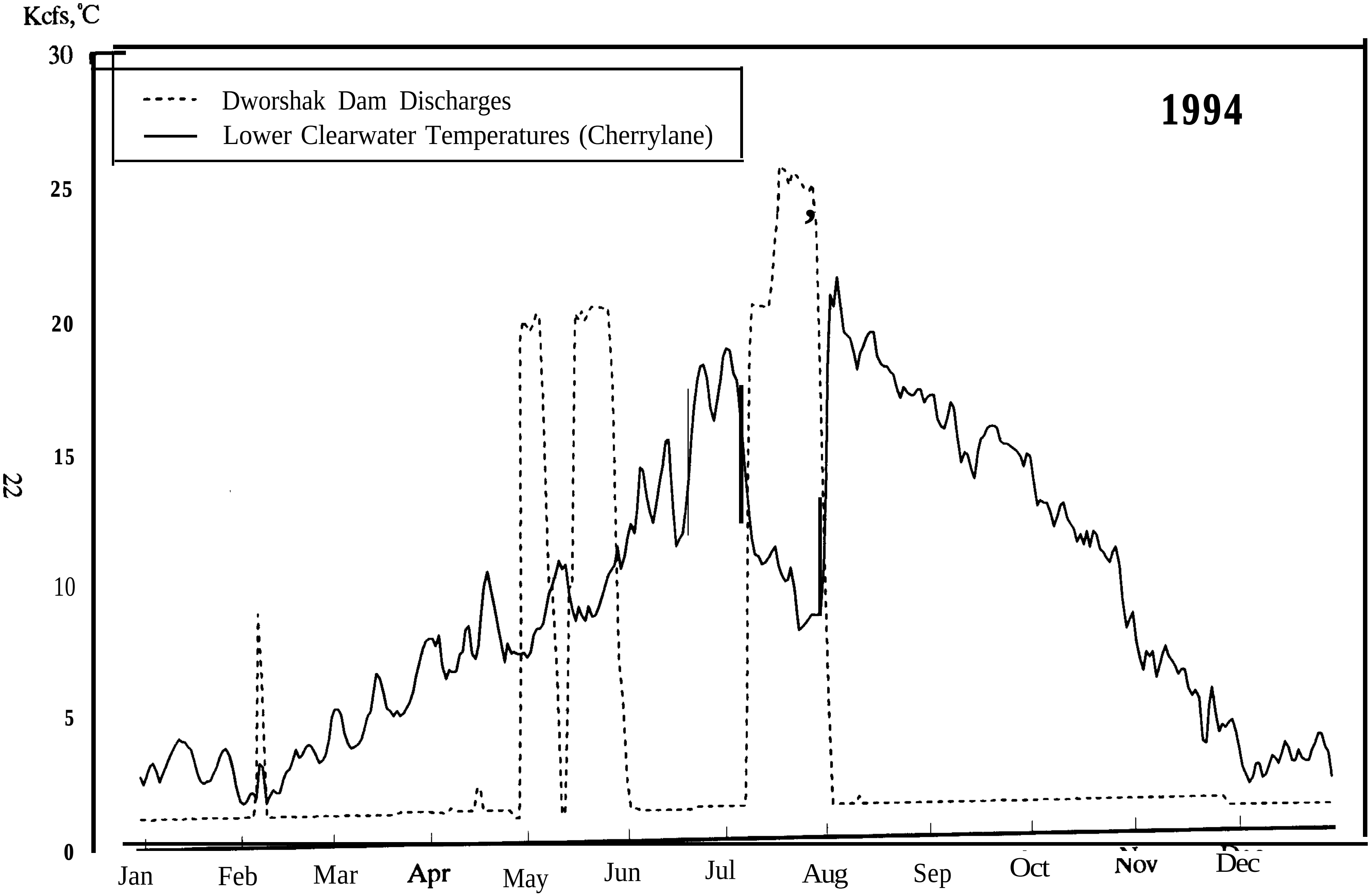

Figure 8. Average daily Dworshak Dam discharges and resultant water temperatures 34 km downstream at Cherry Lane, 1994, Cleawater River, Idaho.

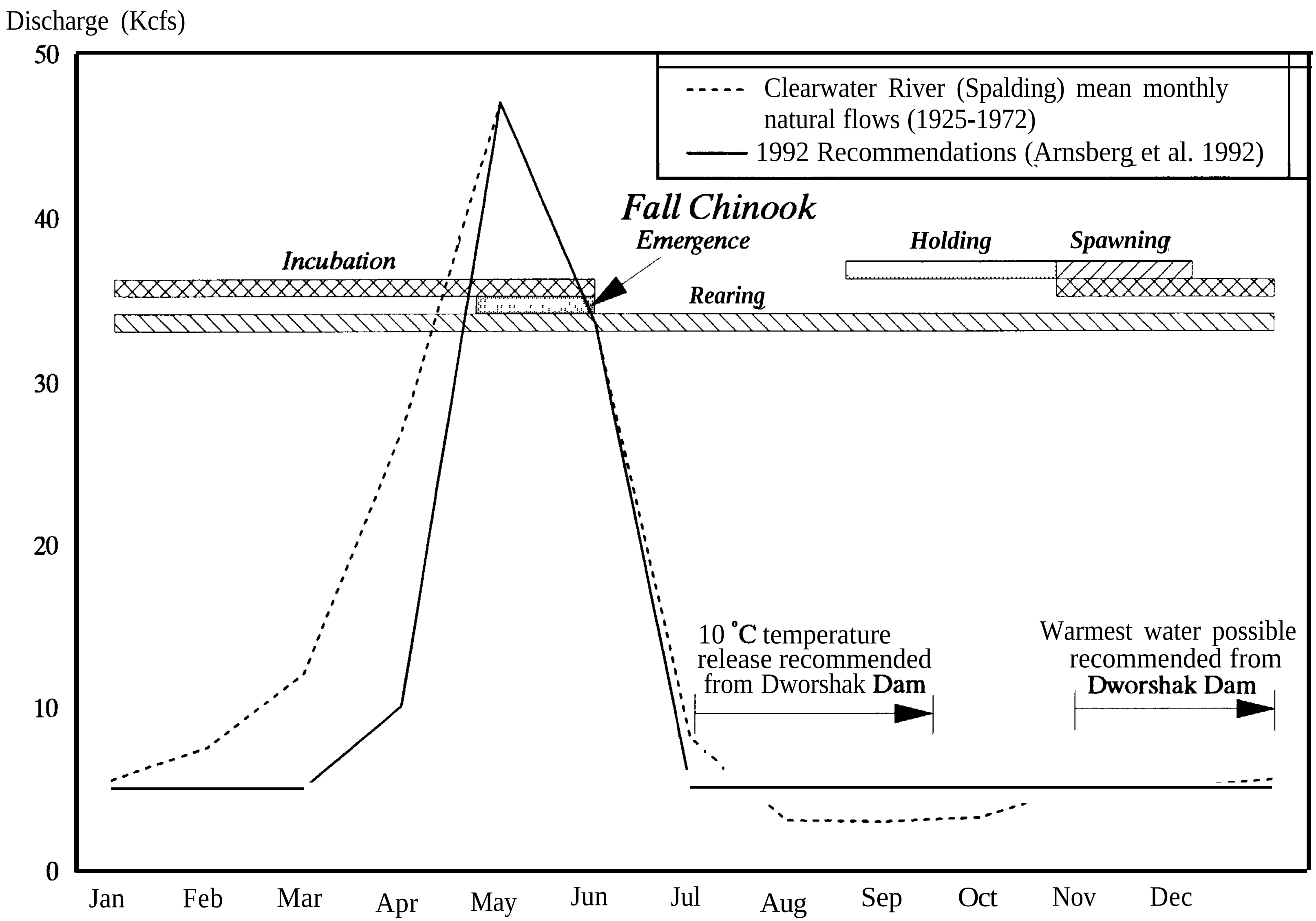

Figure 9. Pre-Dworshak Dam (1925-1972) average monthly discharges for the lower Clearwater River at Spalding, recommended Cleanvater River flows at Spalding and recommended Dworshak Dam release temperatures (Arnsberg et al. 1992), and fall chinook salmon life history periodicity

Inriver flows also influence habitat availability for rearing juvenile salmon. An increase in discharge of the magnitude that occurred in July, 1994, would reduce the lower Clearwater River habitat area for juvenile chinook salmon by about 75 % (Amsberg et al. 1992).

From July 29 to August 1, 1994, Dworshak Dam discharge was reduced from 23,150 cfs to 1,300 cfs (Figure 8, Appendix B), resulting in a reduction of flows on the Cleat-water River at Spalding from 26,800 cfs to 4,310 cfs. Cleat-water River temperatures simultaneously and within four days increased from 8.7 ^{0}C to 20.5 ^{0}C (Appendix B). Such extreme temperature changes in a relative short time period could have direct adverse physiological effects on rearing juvenile chinook salmon.

In summary, anadromous fish inhabiting the Clearwater River did not evolve under the conditions of extreme discharge and temperature fluctuations that occurred during 1994. This type of controlled river operation may potentially alter Clearwater River fall chinook life history characteristics such as outmigration timing, reduce juvenile chinook habitat availability, and cause direct adverse physiological effects on rearing and smolting juvenile salmon. Besides the ESA listed fall chinook salmon, wild A-run and hatchery summer steelhead (0. mykiss) and spring chinook also rear in the lower Clearwater River (Amsberg et al. 1992) and may also be negatively effected by this type of controlled river operation.

RECOMMENDATIONS

The unnatural and potentially damaging Dworshak Reservoir discharge conditions to fall chinook subyearlings in the lower Clearwater River may be moderated in the near term by increased contributions for mainstem flow augmentation from the upper Snake River Basin. To this end, we recommend that the following measures in the Northwest Power Planning Council's 1994 Fish and Wildlife Program (Document 94-55) be aggressively pursued by the Bureau of Reclamation, Bonneville Power Administration, and the States:

"Measure 5.2A.2: Use uncontracted space to supply at least 90,000 acre-feet of water for spring migrants. "

"Measure 5.2A.3: By 1996, provide additional 500,000 acre-feet of water from the Snake River Basin and by 1998 a further 500,000 acre-feet (for a total 1,000,000 acre-feet over and above the 427,000 acre-feet in the Strategy for Salmon's immediate measures and the summer water provided under Section 5.2B) to augment flows in the lower Snake River in the April 10 through September time period."

We further recommend operating Dworshak Dam to meet the Cleat-water River discharge and temperature criteria at Spalding as prescribed in Amsberg et al. (1992). Adequate augmentation of water from the upper Snake River Basin, as identified by the Northwest Power Planning Council, should be targeted for the late summer and early fall period to meet lower Snake River flow objectives.

The 1994 Dworshak Dam operations were driven by the National Marine Fisheries Service (NMFS), pursuant to the Endangered Species Act, primarily to increase Snake River fall chinook subyearling outmigrant survival to the ocean. The thrust was to cool and increase flows in the lower Snake River using Dworshak Reservoir, disregarding potential impacts to ESA listed fall chinook on the lower Clearwater River. Although flows and juvenile survival at mainstem dams are usually positively correlated, there are currently no data available that relates fall chinook salmon smolt-to-adult survival to flows and temperatures in the lower Snake River at the time of juvenile emigration. The NMFS 1995 Biological Opinion summer (July-August) flow target of 50-55 kcfs at Lower Granite Dam is both unnatural and formidable. Without additional flow augmentation from the upper Snake River, disproportionate reliance on Dworshak Reservoir to meet the summer flow target poses a risk to the continued existence of endangered fall chinook in the Clearwater River. The risk of extirpation is particularly acute under the type of flow operations that occurred during 1994.

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APPENDIX A

A PROPOSAL TO MEASURE THE SURVIVAL, TRAVEL TIME, AND GROWTH OF HATCHERY AND WILD FALL CHINOOK SALMON MIGRATING FROM THE CLEARWATER RIVER, IDAHO

Prepared by Billy D. Amsberg, Project Leader
and Cleveland R. Steward, Fisheries Consultant

PROPOSAL SUMMARY

This proposal describes research to be conducted in 1995 by Nez Perce Tribe fisheries biologists, the purpose of which is to quantify key life history characteristics of hatchery and naturally occurring (wild) juvenile fall chinook salmon emigrating from the Clearwater River (Figure Al). The primary objectives are to determine whether hatchery and wild fish survive, travel, and grow at different rates as they traverse the lower Clearwater and Snake rivers, and whether these rates are affected by size and age at release, migration timing, and differences in the condition and health of the fish. Survival and travel rate estimates will be based on detections of PIT-tagged fish at four mainstem hydroelectric dams. This research will provide important insights into migration-related factors operating over relatively short reaches and periods of time.

We propose to obtain 40,000 fall chinook eggs from the 1994 broodyear production group at Lyons Ferry Hatchery (LFH), operated by the Washington Department of Fish and Wildlife. Of these, 27,000 will be reared at LFH for use in survival studies in 1995. The purpose of these studies is to determine whether ***size at release*** or ***time*** of ***release*** (both factors fixed) affects the migratory performance of subyearling fall chinook. Fish will be reared under controlled temperature and feeding regimes to attain two mean sizes - 75 and 95 mm fork length - at the time of their release into the Clearwater River at RK 34 (Cherry Lane). Fish from each size group will be randomly assigned to l,OOO-fish replicates. Four replicates of each size group will be released at l0-day intervals over a three week period (June 20 - July 10). All hatchery subyearling fall chinook will be PIT-tagged six days prior to release, transferred to net pens in the river, and allowed to acclimate for 24 hours prior to release. Paired releases of 75 mm and 95 mm groups of fish will be made at night at 2 h intervals. A total of 24 replicates (i.e., 24,000 subyearling chinook) will be released to evaluate the 2 x 3 Size-Time treatment combinations under a completely randomized factorial design.

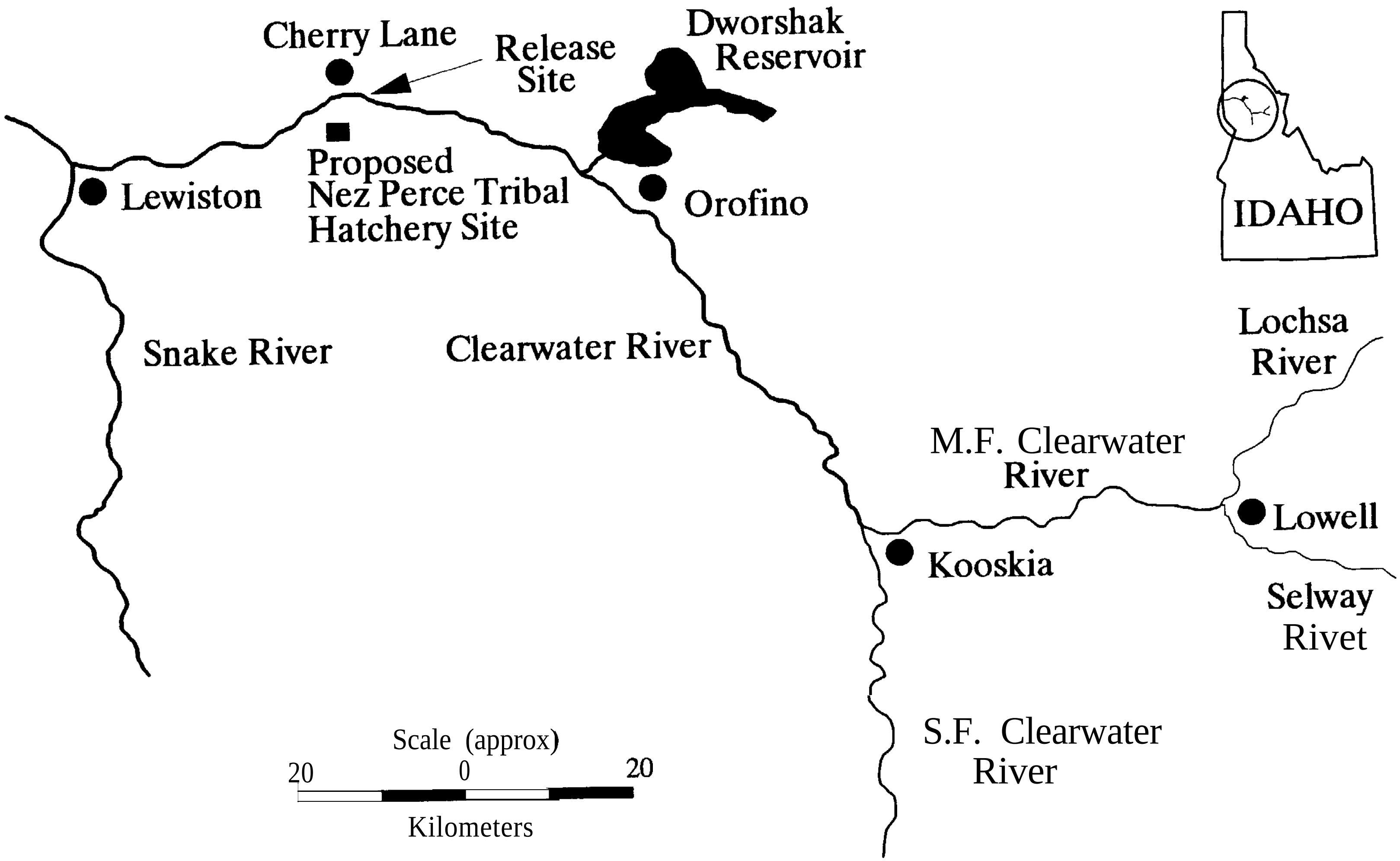

Figure Al. Release site for hatchery fall chinook salmon in the Clearwater River at Cherry Lane (RK 34).

If feasible, one or more replicate groups of wild juvenile fall chinook will be seined from the Clearwater River, PIT-tagged, and released at Cherry Lane together with hatchery fish on the second of the three release dates. Anywhere from 500 to 4,000 wild juvenile fall chinook will be PIT-tagged and released. Measurements of fish length, condition, and smolt status (gill ATPase levels) will be obtained from both hatchery and wild fish at the time of release and their potential effects on survival, etc. will be evaluated. Similarly, the effects of river flow, temperature, and other environmental variables on migration performance will be examined through correlation analysis. We will request that Dworshak Reservoir be controlled so that uniform flow and temperature conditions prevail in the lower Clearwater River over the period of study.

Of the original 40,000 eggs, 13,000 will be transported to Sweetwater Springs Hatchery (operated by the Nez Perce Tribe) where they will be reared for studies to be conducted in 1996. Approximately 10,000 fish, or 77%, are expected to survive to the yearling stage. The eventual disposition of these fish will depend on the outcome of the 1995 experiments. In addition to studies involving subyearling chinook salmon, we propose to evaluate the survival, travel time, and growth of age-l (yearling) hatchery fall chinook released into the Clearwater River in April, 1995. Yearling fall chinook released from Lyons Ferry Hatchery in recent years have returned at 3-4 times the rate observed for subyearlings (Bob Bugert, Washington Department of Fish and Wildlife, pers. comm.), and therefore deserve consideration as a potential tool in rebuilding Clearwater River populations. Yearling fish are less desirable from a supplementation standpoint since they deviate from the subyearling outmigrant life history type characteristic of the species. Nevertheless, the Nez Perce Tribe will investigate the feasibility of using yearling fall chinook to achieve its management goals. A total of 8,000 yearling fall chinook will be obtained from Lyons Ferry Hatchery for release at Cherry Lane in 1995. All of the fish will be PIT-tagged 7-8 days prior to release and randomly assigned to 8 experimental groups of 1,000 fish each. Four of these groups (mean length = 120 mm) will be individually transferred to portable raceways at the site of release and acclimated 30 days prior to release. The remaining four groups of non-acclimated fish will be individually transported and released via hose directly into the river. Releases of paired acclimated/non-acclimated groups will occur at nightfall on four successive nights.

Survival estimates will be obtained through application of the University of Washington's Survival Under Proportional Hazards (SURPH) computer program (Smith et al. 1994). Analysis of variance (or its analog, analysis of deviance) and correlation analysis will be applied to subyearling data to determine which experimental factors were responsible for observed variations in migration performance. A paired t-test will be used to evaluate the null hypothesis of no difference in survival or travel speed of acclimated and non-acclimated yearling fall chinook salmon. Fieldwork and data analyses will be conducted in 1995 by the Nez Perce Tribe with assistance from cooperating agencies. Results will be communicated in the 1995 annual report of the Nez Perce Tribe's summer and fall chinook feasibility study (BPA Contract No. 94BI 12873).

BACKGROUND

As part of their commitment to rebuild wild salmon populations and to restore associated cultural values and activities, the Nez Perce Tribe has embarked on an aggressive, state-of-the-art supplementation program (Larson and Mobrand 1992). The Tribe believes that artificial propagation is necessary to effect the recovery of fall chinook in the Clear-water River system. The proposed research is intended to provide information that can be used to devise appropriate supplementation strategies for this species. This proposal concerns the first year (1995) of a multi-year study. Our immediate objectives are to validate sampling and analytical methods, to determine logistical constraints and, importantly, to collect the empirical data necessary to identify appropriate sample sizes and protocols for future experiments.

Chinook salmon were extirpated from the Clear-water River in 1927 when construction of the Lewiston Dam effectively blocked the upstream migration of returning adults. Prior to their demise, it is believed that fall chinook salmon ranged as far upstream as the Selway River, and were an important food resource for the Nez Perce Tribe. Elimination of chinook populations in the Clearwater River in combination with widespread declines elsewhere in the Snake River basin prompted the National Marine Fisheries Service (NMFS) to list the fall and spring/summer components of this species as threatened in 1992 in accordance with provisions of the Endangered Species Act (ESA). Fall chinook were reclassified as endangered in August 1994 due to anticipated poor returns in 1994 and 1995. In their initial determination, NMFS indicated that only naturally produced fall chinook in the Snake River subbasin warranted protection. The decision to exclude Lyons Ferry Hatchery fall chinook was consistent with NMFS policy at the time; under this policy, hatchery populations of salmon were not considered part of an “Evolutionarily Significant Unit” (ESU) at the time of listing. Thus, fall chinook propagated at Lyons Ferry Hatchery have not been afforded protection under the ESA, even though they possess the genetic and physical/biological attributes of their wild counterparts. According to Mundy (1994), NMFS has reconsidered their policy regarding artificially propagated fish and has recommended that Lyons Ferry Hatchery fall chinook be included in the Snake River ESU.

Although fall chinook (as well as spring/summer chinook) populations were thought to be extirpated within the Clear-water River, small numbers of fall chinook have returned in recent years to spawn in its lower reaches. They possess life history traits associated with Snake River fall chinook, notably October-November spawning in lower elevation mainstem reaches and a protracted downriver migration during their first year of life.

Fall chinook returning to the Clearwater River and to Lyons Ferry Hatchery are leading candidates as sources of broodstock for the Nez Perce Tribal Hatchery fall chinook supplementation program. For this reason, we propose to use both groups of fish as experimental subjects in this study. However, sampling considerations and experimental uncertainties dictate that Lyons Ferry Hatchery fish be used as the primary experimental subjects. Comparable data on naturally occurring fall chinook will be obtained if a sufficient number of juvenile fish can be collected and marked to meet sampling requirements.

The experiments and observational studies described herein have been reviewed by researchers from the University of Washington, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Nez Perce Tribe. Research hypotheses and sampling activities were developed to ensure consistency and cooperation with ongoing research programs. Other agencies and interested parties are invited to review and comment on technical aspects of the study prior to its implementation.

METHODS

Experimental Design

The primary experiment to be conducted in 1995 will investigate whether combinations of two experimental treatments - size of ***release*** with two levels, and ***time*** of ***release*** with three levels - affect the survival probability, rate of travel, and growth of subyearling fall chinook released into the Clearwater River in the vicinity of the proposed site of the central incubation and rearing facility of the Nez Perce Tribal Hatchery (Cherry Lane; RK 34) (see Figure Al). A total of 24,000 hatchery fish will be randomly divided into six subsamples of four replicate groups each (1,000 fish per replicate, 24 replicates in all). The 2 x 3 Size-Time treatment combinations will be randomly assigned to the subsamples, as indicated in the following block diagram:

Time 1 Size 1	Time 1 Size 2	Time 2 Size 1	Time 2 Size 2	Time 3 Size 1	Time 3 Size 2
R_1	R_5	R_9	R_{13}	R_{17}	R_{21}
R_2	R_6	R_{10}	R_{14}	R_{18}	R_{22}
R_3	R_7	R_{11}	R_{15}	R_{19}	R_{23}
R_4	R_8	R_{12}	R_{16}	R_{20}	R_{24}

This experiment is a completely randomized factorial (CRF-23) design in which levels of Size and Time are fixed.[1] The hypotheses associated with the first treatment are that 75 and 95 mm fall chinook will survive, travel, and grow at the same rate over the period of study. The two experimental sizes will be achieved through manipulation of rearing temperatures and diets at Lyons Ferry Hatchery. Intuition suggests that the hypothesis of no size effect is likely to be false. Larger fish are expected to travel more quickly, be less vulnerable to predators, and therefore survive at higher rates than smaller fish. The propensity to migrate may in fact be size related. Significant numbers of subyearling chinook that were captured and PIT-tagged in 1993 in the lower Clearwater River were not detected at downstream dams until 1994. This suggests either (1) a significant portion of the fall chinook endemic to the Clearwater River outmigrate in their second year of life, or (2) the tagged fish were spring chinook that had been misclassified as fall chinook. Our expectation is that all Lyons Ferry Hatchery fall chinook will migrate to the ocean during their first year of life.

Time of release is the second treatment to be investigated under the proposed factorial design. Hatchery-reared fall chinook will be released on three dates spaced 10 days apart, with the second week of release coinciding with the anticipated date of emigration of natural fall chinook from the Clearwater River. The relevant null hypothesis is that no difference in survival, etc. occurs over time, all else being equal. However, variability in performance over time is expected, and likely to depend on the combined effects of several proximate factors, including changes in fish condition, photoperiod, lunar cycle, flow, temperature, dam operations, etc. We will attempt to hold fish size (at 75 and 95 mm), streamflow, and water temperature, constant over the period of study. Flow and temperature will be controlled by varying the amount of water released from Dworshak Dam upstream of the proposed release site.[2] The effects of other variables will be explicitly addressed through correlation and covariance analyses.

If enough naturally occurring fall chinook can be captured, tagged, and released on the same date(s) as hatchery fish, then their respective survival, travel, and growth rates can be compared. We will attempt to collect and PIT-tag at least one replicate group of 500 wild fall chinook and release them at the Cherry Lane release site on the night preceding the second release date of hatchery fish (tentatively June 30). If early results are promising, additional wild fall chinook will be collected and released on the third release date (i.e., 10 days later). As few as 500 and as many as 2,000 wild juvenile fall chinook will be collected and tagged on the two release dates depending on their availability.[3] If four replicate groups,

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1 Although the inferences drawn from this experiment will be confined to the treatment levels tested, the results will be evaluated within the context of levels which may vary from the actual.

2 A formal request will be made of water managers to maintain discharges from Dworshak Reservoir at levels that ensure reasonably uniform flow and temperatures in the lower Clearwater River over the period of study.

3 The number of wild fall chinook allocated per replicate group and the number of replicate groups to be released on each date will be investigated further using power analysis before the study begins.

each numbering 500 wild fish, can be released on a single date, then a paired t-test can be used to test for differences in survival, etc. among hatchery and wild fish. If wild chinook are released on two dates, the hatchery x wild experiment will become a two treatment (Time and Origin) factorial design, analyzable using two-way ANOVA (ANODEV). In addition to hatchery x wild comparisons, it will be possible to determine whether survival among both groups of fish was equally influenced by time of release. A total of 4,000 wild chinook would be needed under this (two release date) design.

Under the proposed design, we assume that hatchery and wild fish are drawn from the same population and that differences among them are due to the effects of hatchery residence and/or time of release. Hatchery fish are not expected to survive or grow as well, nor travel as fast, as wild fish released under similar conditions. One possible complication, mentioned earlier, is that an unknown portion of subyearling chinook residing in the lower Clearwater River may be spring chinook, and therefore not likely to emigrate until their second year of life.

The Nez Perce Tribe is currently evaluating the feasibility of releasing hatchery-reared yearling fall chinook into the Clear-water River in 1995 and beyond. Lyons Ferry Hatchery personnel report a fourfold survival advantage of yearling over subyearling fall chinook (January 1994 memorandum from Bob Bugert, Washington Department of Fish and Wildlife, to Mike DeLarm, NMFS). These survival benefits may have occurred because of larger fish size and/or more favorable flows at time of release (mid-April versus mid-June). Although yearling releases are contrary to supplementation theory, which calls for the production and release of the wild-type subyearling migrant, the potential survival benefit of using larger/older fish warrants further investigation.

It is unclear at this time whether sufficient numbers of yearling fall chinook will be available from Lyons Ferry Hatchery for outplanting in 1995, and whether it is advisable to do so given the current status of the species and our understanding of potential risks and benefits. If the release of yearling fall chinook into the Clearwater River is deemed feasible and appropriate, we propose to investigate their survival, travel, and growth rate using the same mark-recapture techniques that are to be applied to subyearling fish. Specifically, we will obtain 8,000 yearling fall chinook from Lyons Ferry Hatchery and release them at Cherry Lane over a four day period in mid-April. All fish will be randomly assigned to 8 experimental groups of 1,000 fish each. Four of these groups will be individually transferred on successive nights to portable raceways beside the river and acclimated for 30 days prior to release. All of the fish will be PIT-tagged 7-8 days prior to release. After the first group of yearlings has acclimated, the first of four groups of non-acclimated fish will be transported by truck and released via hose directly into the river in the vicinity of the acclimated fish release. The release of the first group of non-acclimated fish will be timed to coincide with the release of the first group of acclimated fish. The remaining groups of acclimated and non-acclimated fish will be released in pairs at 24 h intervals. Releases will occur at nightfall beginning on April 17.

Sampling and Analytical Methods

PIT tags and detectors offer the most reliable means of marking and recapturing experimental fall chinook so that survival rates, passage timing, migration rates, and growth can be estimated. The specific measures of migration performance to be estimated from PIT tag data are:

1. Mean probability of survival for fish migrating from the Cherry Lane release site (RK 34) on the Clear-water River to the Lower Granite Dam tailrace, and thence to Little Goose, Lower Monumental, and McNary dam tailraces;

2. Mean rate of travel (km/hr) between the same points,

3. Median time of passage (recovery) at Lower Granite, Little Goose, Lower Monumental, and McNary dams, and

4. Instantaneous rate of growth (g/day) occurring during transit between points of release and Lower Granite Dam.

A statistical procedure based on the work of Cormack (1964) was adapted by Dr. John Skalski and colleagues at the University of Washington to enable estimates of survival and detection probabilities of PIT-tagged salmon smolts migrating past dams on the mainstem Snake and Columbia rivers. Under Skalski's supervision, researchers from the National Marine Fisheries Service have conducted field studies these past two years on spring chinook and steelhead released into Lower Granite Reservoir and recovered at downstream dams. Preliminary results have been encouraging; estimates of mean survival of relatively high precision have been obtained for both species (Skalski and Giorgi, 1992).

NMFS researchers plan to conduct survival studies in 1995 using juvenile fall chinook collected and released into Lower Granite Reservoir. They will use the same survival estimation methods that were used in earlier studies of spring chinook and steelhead. In the following discussion, it is assumed that "Single-Release" model assumptions and procedures, as described by Dauble et al. (1993) and Iwamoto et al. (1994), will be applicable to mark-recapture data collected from PIT tagged subyearling and yearling fall chinook salmon released into the Clear-water River. If post-detection bypass mortality rates measured in the proposed NMFS study are significant, then their data will be used to correct for bias in our estimates.

Survival estimates based on the Single-Release model require that PIT tag detectors be in operation at two or more dams, that fish detected at upstream dams be diverted back to the river below those dams, and that post-detection mortality due to bypass and release effects be negligible (Dauble et al. 1993). The usual assumptions relating to random and independent samples also apply. PIT-tagged fall chinook released into the Clear-water will be monitored at Lower Granite, Little Goose, Lower Monumental, and McNary dams. Slide gates are expected to be in operation so that fish can be returned to the river at Lower Granite, Little Goose, and Lower Monumental Dams. It is important that PIT-tagged fish are not transported or otherwise "lost" due to detector malfunctions, sampling, or other causes.

The USFWS also plans to investigate fall chinook survival in 1995 with fish size and location of release being the primary experimental variables of interest. Although plans call for diverting untagged juvenile fall chinook into the sampling facility at Lower Granite Dam, these operations are not expected to prevent PIT-tagged fall chinook from being returned unharmed to the river following detection. If a portion of the NPT experimental fish are available for sampling, we propose to anaesthetize approximately 25 fish and take length and weight measurements before returning them to the river. These measurements will serve as the basis for growth rate calculations. As long as the fish are rapidly processed and handled with care, there is no reason to believe that the assumptions of the Single-Release model will be violated. To ensure that sampling does not interfere with ongoing sampling activities at the dam, the Nez Perce Tribe will station a biologist at Lower Granite Dam to sample Clearwater fish and to see that they are released back into the river. Final details relating to sampling at the dam will be reviewed by and coordinated with other researchers.

The rate of travel of subyearling and yearling fall chinook will also be estimated from PIT tag data. Mean travel rate will be used as the basis for comparison among different experimental treatments. The use of median travel time and time of arrival at downstream detection facilities as dependent variables will be limited to comparisons of paired groups of fish released at the same upstream locations.

Sampling Considerations

Sample size calculations were performed to determine the total number of fish to include within the experiment, along with the optimal balance between the number of replicates and the number of fish per replicate. The maximum number of hatchery and wild fish that can reliably be collected, PIT tagged, and released at any one time will need to be determined before a final experimental design and release schedule can be selected. However, the sample sizes recommended below are well within limits established by earlier researchers (Iwamoto et al. 1994).

Although the run is still in progress, it appears that enough adult fall chinook will return to Lyons Ferry Hatchery this year to provide for research needs of the NMFS, USFWS, and Nez Perce Tribe. The Tribe will formally request that 40,000 fall chinook eggs from the 1994 brood be made available for release into the Clearwater River. Of these, 27,000 will be retained at Lyons Ferry Hatchery. The eggs will be randomly divided into three groups which will be exposed to different temperature and feeding regimes to achieve the desired treatment sizes at times of release. Assuming that approximately 92% survive to subyearling stage, a total of 24,000 juveniles should be available for use as experimental subjects.

Approximately 13,000 fall chinook eggs (1994 broodyear) will be transported from Lyons Ferry Hatchery to Sweetwater Springs Hatchery facility, where they will be fertilized and reared to yearling stage. Assuming an egg-to-yearling survival of 77%) approximately 10,000 fish are expected be available for experiments to be conducted in 1996. The focus and direction of these studies will be determined following analysis of data collected in 1995.

Since the total number of juvenile fall chinook available appears sufficient to meet our research needs, the task becomes one of estimating the level of replication needed in the experimental design. We approached this problem by assessing relationships between the expected means and variances in survival as affected by experimental conditions and the size and number of replicates. We would like to be able to detect a difference in survival of approximately 5 - 10% (or higher) if null hypotheses concerning the effects of either location or time of release on survival are in fact false. These values are somewhat arbitrary but are of a magnitude to be of concern to managers. At present, we assume that sample sizes necessary to estimate survival with the desired degree of precision will also yield satisfactory travel rate, median travel time, and time of arrival estimates. This assumption and the relative tradeoffs involved need to be evaluated further before field studies commence.

The precision of survival, travel speed, etc. estimates, and therefore our ability to detect significant differences among experimental groups, will be sensitive to sample size and sampling error (in addition to sources of natural variation), both of which may be controlled to a certain degree. Sampling error will be affected by handling and release procedures, and by fish guidance efficiency, PIT tag detector reliability, and re-release techniques employed at mainstem dams. This source of variance can be reduced by taking steps to improve sampling efficiency, and to minimize recording errors, handling-related mortality, and violations of methodological assumptions.

The sample sizes recommended in this proposal are derived from a consideration of the anticipated number of hatchery and wild fall chinook available, expected differences in survival among treatment groups, recent empirical variance estimates obtained in UW/NMFS survival experiments, and theoretical variance estimates calculated using a computer program (CORMACK) written by Steve Smith of NMFS (formerly of the University of Washington). The program calculates the sampling error (i.e., within-replicate variances) expected of survival estimates for replicates of different size (100 to 1,000 fish) given user-specified survival, detection, and removal probabilities at two or more detection sites. Removal probabilities are estimates of the number of fish detected at a site that for one reason or another never make it back into the river; for our purposes they are the inverse of the slide gate efficiencies. Post-detection mortalities were assumed to be nil. The range of values evaluated for these parameters is summarized in Table Al.

Table A 1. Parameters and values used to calculate the expected precision of survival estimates for fall chinook released into the Clearwater River.

Release size	100 to 1,000 fall chinook
Number of PIT-tag detection sites	4
Reach survival	
Clearwater River to Lower Granite Dam	0.2, 0.4
Lower Granite Dam to Little Goose Dam	0.7
Little Goose Dam to Lower Monumental Dam	0.7
Little Goose Dam to McNary Dam	0.5
Detection probability	
All dams except McNary	0.2 and 0.3
McNary Dam	0.4
Slide gate efficiency (all dams)	0.8

To give some idea of the tradeoffs involved, survival and detection probabilities were selected so that the proportion of fall chinook surviving to and detected at Lower Granite Dam would vary between 20 % and 40%) and 20% and 30%) respectively. The products of these values range from 4% to 12% - well within the range of detection rates observed in recent years for natural fall chinook (USFWS, unpublished data). The number of PIT tag detection sites was set at 4 assuming that all detectors will be operating. We assumed that 70% of the fall chinook would survive between Lower Granite and Little Goose dams. Slide gate efficiencies at all dams were set at 80%. These values were considered reasonable and conservative based upon a review of existing information by NPT, USFWS, and NMFS researchers. Several additional modeling runs were made in addition to those which yielded the results presented below.

All of the proposed experimental designs require replication, so we calculated the precision (standard error) of survival estimates from consideration of theoretical within- and between-replicate variances (Table A2). Standard errors were estimated for 3, 4, 5, and 10 replicates of equal size. We assumed that the variability across replicates was normally distributed such that 95 % would fall within 5 % of the estimated probability of survival from the point of release to Lower Granite Dam. For example, if mean survival to Lower Granite Dam is 0.3, 95% of the replicate survival values would range between 0.25 and 0.35. Iwamoto et al. (1994) reported similar confidence intervals based on empirical estimates of spring chinook survival from lower Snake River hatcheries to Lower Granite Dam (Table A2).

Table A2. Mean survival and estimated 95% confidence intervals for spring chinook salmon released at lower mainstem Snake River hatcheries and recovered at Lower Granite Dam. Data are from Tables 4 and 39 in Iwamoto et al. (1994).

Hatchery	Sample Size	Survival	Mortality	Confidence Limits Lower	Upper
Dworshak	6	0.657	0.027	0.604	0.710
Dworshak	6	0.739	0.031	0.678	0.800
Dworshak	6	0.835	0.061	0.715	0.955
Kooskia	6	0.668	0.043	0.584	0.752
Lookingglass	4	0.672	0.023	0.627	0.717
Lookingglass'	4	0.669	0.025	0.620	0.718

* Fish released into the Imnaha River.

Standard error estimates of mean survival probabilities based on replicate measurements are presented in Table A3 for Clear-water River fall chinook. The tables indicate the relative change in standard error estimates achieved by varying sample sizes and levels of replication. Optimal sample sizes are obtained by balancing the number of fish per replicate with the number of replicates to achieve the highest precision, taking into account the magnitude of expected differences in mean survival among experimental groups. The standard errors listed in Table A3 can be used to calculate the minimum detectable difference between means for a specified sample size, standard error, and level of significance. For example, standard errors ranging from 0.026 to 0.05 1 will enable detection of survival means lying 5% to 10% apart. The lower the standard error (i.e., the higher the precision), the better are our chances of detecting truly significant differences among sample means.

Several generalizations could be drawn from our computer simulations, including those runs that gave rise to Table A3:

1. Under the assumed distributions of replicate means, precision is negatively related to survival probability;
2. Precision goes up with the number of detection facilities;
3. Precision is positively related to detection probability;

Table A3. Expected standard error of estimated survival probabilities of fall chinook released in the Clearwater River and migrating to Lower Granite Dam.

Case Al. Survival probability = 0.2, detection probability = 0.2,

Number per Replicate	Number of Replicates - 3 -	- 4 -	-5-	- 10 -
100	0.096	0.083	0.074	0.053
200	0.068	0.059	0.053	0.037
300	0.057	0.049	0.044	0.031
400	0.050	0.043	0.039	0.027
500	0.045	0.039	0.035	0.025
600	0.041	0.036	0.032	0.022
700	0.039	0.034	0.030	0.021
800	0.037	0.032	0.029	0.020
900	0.035	0.030	0.027	0.019
1000	0.033	0.029	0.026	0.018

Case A2. Survival probability = 0.2, detection probability = 0.3.

Number per Replicate	Number of Replicates - 3 -	- 4 -	-5-	- IO-
100	0.063	0.083	0.074	0.053
200	0.046	0.059	0.053	0.037
300	0.038	0.049	0.044	0.031
400	0.034	0.043	0.039	0.027
500	0.031	0.039	0.035	0.025
600	0.029	0.036	0.032	0.022
700	0.027	0.034	0.030	0.021
800	0.026	0.032	0.029	0.020
900	0.025	0.030	0.027	0.019
1000	0.024	0.029	0.026	0.018

Table A3. Continued.

Case B1. Survival probability = 0.4, detection probability = 0.2.

Number per Replicate	Number of Replicates -3-	-4-	-5-	-10-
100	0.134	0.116	0.104	0.073
200	0.095	0.082	0.074	0.052
300	0.078	0.068	0.060	0.043
400	0.068	0.059	0.053	0.037
500	0.061	0.053	0.047	0.033
600	0.056	0.048	0.043	0.031
700	0.052	0.045	0.040	0.028
800	0.049	0.042	0.038	0.027
900	0.047	0.041	0.036	0.026
1000	0.440	0.381	0.341	0.241

Case B2. Survival probability = 0.4, detection probability = 0.3.

Number per Replicate	Number of Replicates -3-	-4-	-5-	-10-
100	0.086	0.116	0.104	0.073
200	0.062	0.082	0.074	0.052
300	0.051	0.068	0.060	0.043
400	0.045	0.059	0.053	0.037
500	0.041	0.053	0.047	0.033
600	0.038	0.048	0.043	0.031
700	0.035	0.045	0.040	0.028
800	0.033	0.042	0.038	0.027
900	0.032	0.041	0.036	0.026
1000	0.031	0.381	0.341	0.241

4. Replication, even in small numbers, greatly increases precision. However, incremental gains in precision decrease as the number of replicates increases; and
5. For a finite number of fish, it usually makes more sense to create more replicates rather than increase the number of fish per replicate. This is especially true at higher survival probabilities.

From the foregoing, we recommend that no fewer than 4 replicate groups of subyearling fall chinook be allocated per treatment combination with 800-l ,000 fish comprising each replicate. It will be generally advantageous to standardize the size of (number of fish per) replicates and to release fish under conditions in which only the treatment is allowed to vary. If it proves impossible to achieve true replication within treatment groups, the four replicates will be combined into a single replicate for each Size-Time combination. Regardless of the final number of replicates, experimental data will be analyzable using two-way ANOVA (ANODEV). However, if only one replicate is obtained, it will not be possible to compute a within-cell estimate of experimental error. In this case, experimental error will be estimated from Size-Time interaction under the (dubious) assumption that the effects of one variable do not vary across levels of the second (i.e., interaction effects are equal to zero). Since this calculation and the associated loss of power is undesirable, we will attempt to achieve replication through random and equal allocation of fish to treatment groups.

Sensitivity analyses of yearling fall chinook survival based on the CORMACK model have yet to be run. Our request for 8,000 is predicated on the need to achieve sufficient precision and replication to test the hypothesis of interest (i.e., acclimation versus no acclimation of yearling fish prior to release). Our recommendations will be refined further after fall chinook data obtained during the 1994 field season have been fully analyzed.

One of the primary purposes for attempting survival estimates this year is to obtain more precise estimates of mean survival and inter-replicate variability. We note that in conjunction with the USFWS and NMFS studies, a range of fall chinook release sizes, times, and locations will be evaluated in 1995 in order to better define the magnitude and variability in survival expected over a range of natural conditions. These results will be used to devise future experiments that are sufficiently powerful to correctly reject null hypotheses of interest, when they are in fact false. Clearly, this approach is preferred over experiments that are conducted without prior knowledge of the variability and size of the treatment effect.

Source, Collection, and Care Of Fish

A total of 40,000 subyearling and 8,000 yearling fall chinook from Lyons Ferry Hatchery will be needed for experimental purposes. The need for eggs is most pressing; the decision regarding yearling fall chinook can be deferred until later. Our preference is that all experimental fish come from Lyons Ferry Hatchery broodstock rather than from returning adults of unknown parentage collected at Lower Granite Dam. The eggs should be collected from as many female x male spawner pairings as possible and randomly mixed to ensure genetic heterogeneity among experimental groups of fish. Water temperatures and food rations will be carefully controlled so that the fish are approximately 75 and 95 mm in size at the time of release. The Nez Perce Tribe will offer assistance as necessary to Lyons Ferry Hatchery personnel in the care of fish at that hatchery.

The 13,000 eggs destined for Sweetwater Springs Hatchery (approximately 2.5 hours by road from Lyons Ferry Hatchery) will be transported as unfertilized ova along with sperm from a representative sample of males. Once at the hatchery, the eggs will be fertilized and placed in stack tray incubators. After hatching and buttoning up, juvenile chinook will be raised to yearling stage following standard hatchery procedures. This method of collecting, transporting, and fertilizing eggs has been used successfully in the past by Nez Perce Tribal hatchery personnel (Larson and Mobrand 1992) and it enables greater control over developmental rates via temperature control.

Anywhere from 500 to 2,000 wild juvenile fall chinook will be collected by beach seining and minnow trapping in known rearing areas in the lower Cleat-water River during the week preceding the second release date. Another 500 to 2,000 fish sample may be collected prior to the third release date if results of the first release are encouraging. Captured wild fish will be PIT tagged on site, divided into 500-fish groups, and held under low-light (shaded), low-velocity (0.5 - 1.0 fps) conditions in net pens until time of release. A second sample of wild fish will be collected in Week 2 and 3 if numbers permit.

Tagging and Release Procedures

Standard anesthesiological and PIT-tagging protocols will be followed. PIT-tagged fish will be allowed to fully recover before release. Fish transferred to net pens will be allowed to acclimate for a minimum of 24 hours, but will be held no longer than 5 days prior to release. Net pens will be spacious, shaded, secure from predators, and located in low velocity areas. All fish will be fed reduced rations while confined in net pens. PIT tag retention and the number and PIT-tag codes of fish that die from handling/tagging will be determined at the time of release.

Wild fall chinook used in the experiments will be tagged, transported, acclimated, and released in the same way as hatchery fish. For subyearling chinook, staggered releases of hatchery and wild fall chinook are recommended so that the groups move more-or-less independently downstream following liberation. The first release of fish will be made immediately after dark, followed by second, third and fourth paired releases at 2 hour intervals.

Concomitant Variables

There are several factors other than those to be applied as experimental treatments that have the potential to affect the survival, timing, rate of migration, and growth of fall chinook. These variables, classified as endogenous and exogenous depending on their source, will be measured at the time that fall chinook are released and, if possible, in samples collected at Lower Granite Dam. The primary exogenous variables are photoperiod, lunar cycle, water temperature, mean water velocity, turbidity, water chemistry (dissolved oxygen levels, pH, contaminant concentrations), and predator activity and density. The primary endogenous variables are fish size, fish health, and physiological status (gill ATPase levels and other measures of smoltification). Past studies suggest that these variables interact in complex ways to affect survival, travel time, etc., so it is unlikely that simple statistical relationships will be discerned from the data. Interrelationships among dependent and independent (concomitant) variables should be explored using multivariate techniques (e.g., multiple regression, factor analysis).

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APPENDIX B

Table Bl. Daily average, maximum, and minimum water temperatures measured in the lower Clearwater River at Cherry Lane (River km 34), Clearwater River at Orofino (River km 68), and Selway River below Selway Falls (River km 30), and Dworshak Dam discharges, 1993-1994.

	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
Date	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
10/01/93	13.5	14.0	13.0	14.5	16.1	13.3	11.3	11.8	10.8	1.21
10/02/93	13.3	14.0	12.5	14.4	15.9	13.1	11.2	11.8	10.8	1.20
10/03/93	13.5	14.5	12.5	14.2	15.9	12.8	11.0	11.5	10.6	1.20
10/04/93	13.5	14.5	12.5	14.1	15.7	12.8	10.8	11.5	10.4	1.20
10/05/93	13.5	14.0	13.0	14.1	15.4	12.8	10.7	11.2	10.3	1.20
10/06/93	13.5	14.0	13.0	13.8	14.5	13.0	11.0	11.5	10.5	1.21
10/07/93	13.0	13.5	12.5	13.6	14.0	13.2	11.2	11.3	11.0	1.21
10/08/93	12.3	12.5	12.0	12.8	13.4	11.8	10.7	11.0	10.3	1.21
10/09/93	11.5	12.0	11.0	11.7	12.6	10.9	9.4	10.1	8.9	1.20
10/10/93	11.0	12.0	10.0	11.2	12.1	10.2	8.5	9.0	7.8	1.22
10/11/93	11.5	12.0	11.0	11.5	12.3	10.6	8.1	8.5	7.9	1.21
10/12/93	11.8	12.5	11.0	12.2	13.1	11.4	8.8	9.2	8.1	1.22
10/13/93	12.0	12.5	11.5	12.6	13.2	12.2	9.3	9.6	8.9	1.21
10/14/93	11.8	12.0	11.5	12.4	13.1	11.9	9.8	10.1	9.5	1.21
10/15/93	11.8	12.0	11.5	12.2	13.1	11.8	10.1	10.3	9.8	1.20
10/16/93	11.8	12.0	11.5	12.0	12.4	11.8	10.2	10.3	10.0	1.20
10/17/93	11.3	11.5	11.0	11.6	11.8	11.3	10.1	10.3	10.0	1.20
10/18/93	11.3	11.5	11.0	11.6	12.1	11.2	9.6	10.0	9.0	1.21
10/19/93	11.3	11.5	11.0	11.1	11.8	10.3	8.7	9.0	8.2	1.20
10/20/93	10.5	11.0	10.0	9.8	10.8	9.2	7.6	8.1	7.0	1.20
10/21/93	10.3	10.5	10.0	8.9	9.5	8.5	6.6	6.9	6.2	1.20
10/22/93	10.0	10.5	9.5	8.7	9.5	8.0	6.0	6.4	5.6	1.20
10/23/93	10.0	10.5	9.5	8.7	9.5	8.0	5.8	6.0	5.6	1.21
10/24/93	10.3	10.5	10.0	8.9	9.6	8.3	6.2	6.6	5.7	1.21
10/25/93	9.5	10.0	9.0	8.4	9.5	7.8	5.9	6.2	5.3	1.20
10/26/93	9.0	9.5	8.5	7.4	8.3	6.6	5.1	5.6	4.6	1.20
10/27/93	8.8	9.0	8.5	6.7	7.4	6.0	4.5	4.7	4.2	1.20
10/28/93	9.0	9.0	9.0	6.9	7.4	6.5	4.8	5.3	4.3	1.20
10/29/93	8.5	9.0	8.0	6.8	7.7	6.0	4.8	5.1	4.5	1.21

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
10/30/93	8.0	8.5	7.5	6.1	6.9	5.6	4.0	4.6	3.5	1.20
10/31/93	7.8	8.0	7.5	5.3	5.7	5.0	3.4	3.7	3.2	1.20
11/01/93	7.8	8.0	7.5	5.0	5.7	4.6	3.4	3.6	3.2	1.21
11/02/93	7.3	7.5	7.0	4.9	5.4	4.4	3.3	3.5	3.1	1.20
11/03/93	8.0	8.5	7.5	5.4	6.0	4.7	3.9	4.2	3.3	1.50
11/04/93	7.5	7.6	7.1	5.9	6.5	5.3	4.3	4.5	4.1	1.21
11/05/93	7.2	7.9	6.7	5.7	6.7	4.9	4.3	4.5	4.0	1.20
11/06/93	6.8	7.4	6.4	4.9	5.6	4.4	3.7	4.0	3.4	1.20
11/07/93	6.3	6.8	5.7	4.0	4.5	3.6	3.5	3.7	3.1	1.20
11/08/93	5.8	6.4	5.2	3.6	4.5	3.0	2.6	3.2	2.0	1.32
11/09/93	5.5	6.0	5.2	2.9	3.3	2.5	1.9	2.0	1.6	1.21
11/10/93	6.0	6.8	5.4	2.9	3.8	2.4	1.8	2.0	1.6	1.21
11/11/93	5.5	6.3	5.0	2.8	3.7	2.0	1.2	1.5	0.8	1.21
11/12/93	5.2	5.6	4.8	2.1	2.4	1.8	0.9	1.1	0.7	1.21
11/13/93	4.5	4.8	4.2	1.5	1.9	1.1	1.2	1.5	0.9	1.22
11/14/93	4.8	5.5	4.2	2.0	2.4	1.5	1.6	1.9	1.4	1.21
11/15/93	4.9	5.3	4.5	2.3	2.9	1.6	1.6	1.7	1.5	1.20
11/16/93	5.3	5.8	4.7	2.8	3.2	2.4	1.8	2.1	1.5	1.20
11/17/93	5.8	6.0	5.5	3.3	3.6	2.8	2.4	2.7	2.0	1.21
11/18/93	5.6	6.2	5.0	3.6	4.3	3.2	2.9	3.2	2.7	1.21
11/19/93	4.9	5.3	4.4	3.1	3.9	2.5	2.5	2.8	2.1	1.20
11/20/93	4.5	5.0	4.2	2.2	2.8	1.6	1.6	2.0	1.1	1.21
11/21/93	4.5	4.8	4.0	1.8	2.0	1.5	1.0	1.1	0.8	1.21
11/22/93	4.7	5.0	4.3	1.7	2.1	1.3	1.0	1.1	0.7	1.20
11/23/93	3.6	4.2	2.7	0.9	1.4	0.3	0.2	0.7	-0.1	1.21
11/24/93	1.9	2.7	0.6	0.1	0.4	-0.1	0.1	0.6	-0.1	1.20
11/25/93	1.2	1.8	0.3	0.1	0.3	0.0	0.0	0.2	-0.1	1.22
11/26/93	1.3	1.9	0.7	0.1	0.3	0.0	0.1	0.1	-0.1	1.21
11/27/93	1.8	2.5	1.1	0.1	0.3	0.0	0.1	0.2	-0.1	1.20
11/28/93	3.3	3.8	2.5	0.1	0.2	0.1	0.1	0.3	-0.1	1.21
11/29/93	3.7	4.2	3.4	0.2	0.3	-0.1	0.1	0.2	-0.1	1.21
11/30/93	3.2	3.6	2.9	0.3	0.6	0.1	0.2	0.6	0.1	1.21
12/01/93	3.2	3.3	3.0	0.3	0.4	-0.1	0.2	0.3	0.1	1.21
12/02/93	3.1	3.4	2.9	0.4	0.9	0.2	0.2	0.6	0.1	1.20

Date	Clearwater River temps. (Cherry Lane) Ave.	Max.	Min.	Clearwater River temps. (Orofino) Ave.	Max.	Min.	Selway River temps. (Selway Falls) Ave.	Max.	Min.	Dworshak Discharges[a] (Kcfs)
12/03/93	3.0	3.3	2.9	0.4	0.7	0.3	0.3	0.4	0.1	1.21
12/04/93	3.1	3.5	2.9	0.6	0.8	0.3	0.4	0.6	0.3	1.20
12/05/93	2.8	3.2	2.3	0.4	0.8	0.1	0.3	0.4	0.3	1.20
12/06/93	2.2	2.5	2.0	0.2	0.7	0.0	0.1	0.2	-0.1	1.21
12/07/93	2.6	2.9	2.2	0.2	0.4	0.0	0.2	0.3	0.0	1.21
12/08/93	3.1	3.3	2.5	0.5	0.6	0.3	0.4	0.6	0.3	1.21
12/09/93	3.2	3.4	2.9	0.7	1.2	0.5	0.5	0.7	0.3	1.21
12/10/93	3.6	3.9	3.3	1.1	1.6	0.7	0.7	1.2	0.4	1.20
12/11/93	3.7	3.9	3.5	1.5	1.8	1.1	1.1	1.3	0.9	1.21
12/12/93	3.5	3.8	3.2	1.9	2.3	1.5	1.5	1.9	1.3	1.20
12/13/93	3.1	3.3	2.8	1.4	1.6	1.2	1.0	1.6	0.7	1.20
12/14/93	3.2	3.6	2.9	1.2	1.6	1.0	0.7	0.9	0.5	1.15
12/15/93	3.1	3.4	2.8	1.5	1.8	1.1	0.7	0.9	0.5	1.20
12/16/93	3.7	4.0	3.3	1.7	1.9	1.5	1.1	1.3	0.8	1.21
12/17/93	3.6	3.8	3.5	1.8	2.0	1.6	1.4	1.6	1.2	1.22
12/18/93	3.5	3.8	3.3	1.8	2.2	1.6	1.3	1.6	1.0	1.22
12/19/93	3.3	3.4	3.2	1.4	1.6	1.3	1.1	1.3	1.0	1.22
12/20/93	3.3	3.8	3.0	1.4	1.9	1.1	0.9	1.2	0.7	1.21
12/21/93	3.2	3.5	3.0	1.5	1.7	1.1	0.8	1.0	0.6	1.22
12/22/93	3.1	3.4	2.9	1.4	1.6	1.1	0.5	0.7	0.4	1.22
12/23/93	2.8	3.2	2.5	1.2	1.7	0.8	0.4	0.6	0.3	1.22
12/24/93	2.5	3.0	2.0	0.8	1.4	0.3	0.1	0.3	-0.1	1.22
12/25/93	2.0	2.5	1.6	0.2	0.6	0.0	0.1	0.1	-0.1	1.21
12/26/93	2.1	2.4	1.8	0.1	0.3	0.1	0.1	0.1	0.0	1.21
12/27/93	2.5	2.7	2.1	0.2	0.3	0.1	0.1	0.3	0.0	1.22
12/28/93	2.4	2.9	2.1	0.2	0.7	-0.1	0.0	0.1	-0.1	1.20
12/29/93	2.0	2.5	1.8	0.2	0.5	-0.1	0.1	0.2	-0.1	1.21
12/30/93	2.3	2.5	2.0	0.2	0.4	-0.2	0.2	0.3	-0.1	1.21
12/31/93	2.7	3.3	2.2	0.4	0.9	0.0	0.2	0.4	0.0	1.21
01/01/94	2.8	2.9	2.5	0.5	0.6	0.2	0.3	0.3	0.1	1.21
01/02/94	2.5	2.7	2.4	0.7	0.9	0.6	0.4	0.6	0.2	1.21
01/03/94	2.9	3.2	2.4	1.1	1.5	0.7	0.6	0.7	0.5	1.21
01/04/94	3.2	3.3	2.9	1.9	2.2	1.4	0.9	1.1	0.5	1.18
01/05/94	3.3	3.4	3.1	2.2	2.4	1.9	1.4	1.6	1.1	1.19

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
01/06/94	3.0	3.3	2.8	2.2	2.5	1.8	1.4	1.6	1.3	1.21
01/07/94	2.6	2.8	2.4	1.8	2.0	1.6	1.1	1.3	1.0	1.21
01/08/94	2.9	3.2	2.6	1.8	1.9	1.5	1.1	1.1	1.0	1.21
01/09/94	3.2	3.5	3.0	2.1	2.5	1.9	1.2	1.4	1.0	1.21
01/10/94	3.5	3.7	3.2	2.6	2.9	2.1	1.6	1.9	1.3	1.21
01/11/94	3.8	4.2	3.6	2.8	3.2	2.5	1.8	2.2	1.6	1.21
01/12/94	4.0	4.5	3.7	3.1	3.3	2.9	2.0	2.1	1.6	1.20
01/13/94	4.2	4.5	3.7	3.5	3.7	3.3	2.3	2.5	2.1	1.20
01/14/94	4.1	4.5	3.7	3.6	3.8	3.4	2.4	2.5	2.4	1.20
01/15/94	4.1	4.2	3.8	3.4	3.7	3.2	2.6	3.2	2.4	1.21
01/16/94	3.9	4.2	3.7	3.5	3.8	3.1	2.9	3.2	2.6	1.21
01/17/94	3.8	4.2	3.5	3.5	4.0	2.9	2.8	3.2	2.6	1.21
01/18/94	3.4	3.7	3.1	2.8	3.3	2.1	2.3	2.6	2.1	1.20
01/19/94	2.9	3.3	2.4	2.1	2.5	1.6	1.9	2.1	1.6	1.21
01/20/94	2.6	3.2	2.3	1.6	2.1	1.1	1.3	1.7	0.8	1.21
01/21/94	2.5	2.8	2.4	1.2	1.6	0.8	0.9	1.1	0.7	1.21
01/22/94	2.6	3.1	2.3	1.3	1.9	0.9	1.0	1.2	0.8	1.21
01/23/94	2.6	2.9	2.5	1.5	1.7	1.0	1.0	1.2	0.8	1.21
01/24/94	2.9	3.4	2.5	1.8	2.2	1.4	1.1	1.2	0.8	1.22
01/25/94	3.1	3.3	2.9	2.0	2.3	1.5	1.0	1.1	0.7	1.22
01/26/94	3.5	3.7	3.3	2.5	2.9	2.0	1.5	1.7	1.1	1.21
01/27/94	3.7	4.5	3.4	2.9	3.2	2.4	2.0	2.3	1.7	1.20
01/28/94	3.8	4.2	3.4	3.0	3.5	2.8	1.9	2.1	1.5	1.20
01/29/94	3.5	3.7	3.0	2.8	3.1	2.4	1.4	1.6	1.2	1.20
01/30/94	3.0	3.7	2.4	2.1	2.9	1.4	1.0	1.3	0.5	1.20
01/31/94	2.3	2.9	1.5	1.1	2.0	0.3	0.2	0.4	-0.1	1.20
02/01/94	1.8	2.6	1.2	0.4	1.3	0.0	0.1	0.1	-0.1	1.22
02/02/94	1.7	2.4	1.1	0.2	1.1	0.0	0.1	0.3	-0.1	1.21
02/03/94	1.8	2.1	1.5	0.2	0.8	-0.2	0.0	0.1	-0.1	1.21
02/04/94	2.1	2.4	1.8	0.2	0.5	-0.1	0.1	0.2	-0.1	1.21
02/05/94	2.1	2.8	1.6	0.3	1.2	0.0	0.1	0.2	-0.2	1.21
02/06/94	1.9	2.8	1.2	0.4	1.2	0.0	0.1	0.3	-0.1	2.20
02/07/94	3.2	3.6	2.3	0.2	0.5	0.0	0.1	0.1	-0.1	8.82
02/08/94	3.1	3.6	2.3	0.1	0.6	0.0	0.1	0.3	-0.1	6.38

Date	Clearwater River temps. (Cherry Lane) Ave.	Max.	Min.	Clearwater River temps. (Orofino) Ave.	Max.	Min.	Selway River temps. (Selway Falls) Ave.	Max.	Min.	Dworshak Discharges[a] (Kcfs)
02/09/94	1.7	2.2	1.1	0.1	0.2	0.0	0.1	0.1	-0.1	1.20
02/10/94	2.0	2.8	1.2	0.4	1.1	0.0	0.1	0.3	0.0	1.20
02/11/94	2.2	2.9	1.7	0.3	0.9	0.0	0.1	0.3	-0.1	1.20
02/12/94	2.1	2.7	1.8	0.4	1.1	0.0	0.2	0.6	-0.1	1.21
02/13/94	2.1	2.2	1.9	0.5	0.7	0.1	0.1	0.3	-0.1	1.21
02/14/94	2.6	3.4	1.8	1.1	2.0	0.3	0.2	0.3	-0.1	1.21
02/15/94	2.9	3.5	2.4	1.5	2.0	0.8	0.2	0.3	0.0	1.21
02/16/94	3.0	3.7	2.5	1.6	2.2	1.2	0.3	0.5	0.1	1.21
02/17/94	3.3	3.5	3.0	1.9	2.2	1.5	0.3	0.4	0.2	1.21
02/18/94	3.7	4.7	2.9	2.4	3.2	1.8	0.4	0.6	0.3	1.20
02/19/94	3.4	4.0	3.0	2.3	3.0	1.9	0.3	0.6	-0.1	1.20
02/20/94	3.5	4.2	2.8	2.3	3.0	1.5	0.3	0.5	-0.1	1.20
02/21/94	3.8	4.6	3.1	2.5	3.0	1.9	0.4	0.7	0.3	1.20
02/22/94	3.9	4.5	3.3	3.0	3.8	2.4	0.5	0.7	0.3	1.20
02/23/94	3.8	4.0	3.3	3.0	3.3	2.8	0.3	0.6	0.1	1.20
02/24/94	3.5	4.1	2.9	2.9	3.6	2.4	0.2	0.3	-0.1	1.21
02/25/94	3.2	3.4	2.8	1.9	2.4	1.3	0.2	0.3	0.1	1.21
02/26/94	3.3	3.8	2.6	1.8	2.4	1.2	0.5	0.8	0.0	1.22
02/27/94	3.5	3.8	3.3	2.8	3.3	2.1	0.8	1.1	0.4	1.22
02/28/94	4.1	4.8	3.4	3.5	3.9	3.1	1.0	1.1	0.8	1.22
03/01/94	4.9	5.3	4.2	4.4	5.1	3.6	1.6	2.0	1.1	1.21
03/02/94	5.2	5.4	4.8	4.7	5.3	4.2	1.8	2.1	1.5	1.20
03/03/94	5.2	5.6	4.7	4.6	5.3	4.2	2.2	2.6	1.7	1.20
03/04/94	5.0	5.5	4.6	4.4	4.9	3.6	2.7	3.2	2.4	1.21
03/05/94	4.3	4.8	3.8	3.7	4.2	3.2	2.8	3.5	2.5	1.21
03/06/94	3.9	4.5	3.3	3.5	4.0	3.2	2.8	3.2	2.5	1.21
03/07/94	3.7	4.3	2.8	3.3	3.7	2.9	2.2	2.5	1.6	1.21
03/08/94	3.8	4.5	2.9	3.3	4.2	2.8	2.3	2.6	1.7	1.21
03/09/94	3.9	4.5	2.8	3.5	4.3	2.8	2.3	2.7	1.9	1.20
03/10/94	4.1	4.6	3.4	3.6	4.0	3.3	2.6	2.9	2.1	1.20
03/11/94	4.5	5.0	3.9	4.1	4.7	3.6	3.3	3.7	2.9	1.20
03/12/94	4.9	5.5	3.9	4.7	5.6	4.0	3.8	4.2	3.3	1.20
03/13/94	5.1	5.5	4.4	5.2	5.9	4.5	4.0	4.3	3.4	1.20
03/14/94	5.8	6.4	4.9	5.6	6.6	4.7	4.2	4.6	3.6	1.20

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
03/15/94	6.5	7.1	5.4	6.3	7.3	5.4	4.5	4.9	3.7	1.21
03/16/94	6.3	6.7	5.9	6.3	6.7	5.9	4.6	4.9	3.8	1.20
03/17/94	5.8	6.0	5.3	5.3	5.7	5.1	4.2	4.5	3.8	1.20
03/18/94	5.2	5.3	4.9	5.1	5.3	4.9	4.0	4.4	3.5	1.20
03/19/94	5.1	5.6	4.6	4.7	4.9	4.4	4.4	4.8	3.9	1.20
03/20/94	4.9	5.3	4.2	4.7	4.9	4.5	4.0	4.2	3.8	1.20
03/21/94	5.1	5.5	4.6	5.0	5.3	4.6	4.0	4.2	3.7	1.26
03/22/94	4.9	5.5	4.4	4.7	5.1	4.2	3.7	4.2	3.3	1.30
03/23/94	5.0	5.6	4.2	4.8	5.4	4.2	3.7	4.2	3.1	1.30
03/24/94	5.2	6.0	4.2	4.8	5.7	4.3	3.6	4.0	3.0	1.29
03/25/94	5.4	6.0	4.2	5.0	6.1	4.2	3.4	4.2	2.5	1.30
03/26/94	5.8	6.5	4.6	5.5	6.7	4.6	3.7	4.3	2.8	1.30
03/27/94	6.4	7.1	5.2	6.1	7.2	5.3	4.4	4.9	3.4	1.30
03/28/94	6.9	7.6	5.7	6.7	7.8	5.7	4.8	5.4	3.9	1.29
03/29/94	7.4	8.2	6.2	7.1	8.1	6.1	5.3	6.0	4.4	1.29
03/30/94	7.7	8.5	6.4	7.5	8.3	6.7	5.4	5.9	4.5	1.29
03/31/94	7.8	8.9	7.0	7.7	8.2	7.2	5.5	6.2	4.7	1.27
04/01/94	7.8	8.6	7.3	7.3	7.7	6.7	5.7	6.3	5.2	1.26
04/02/94	7.5	8.2	6.5	7.3	8.3	6.3	6.0	6.4	5.5	1.25
04/03/94	7.9	8.5	7.4	7.8	8.5	7.0	5.7	6.2	5.0	1.24
04/04/94	6.8	7.5	6.0	6.2	6.8	5.8	4.9	5.4	4.6	1.23
04/05/94	6.3	6.7	5.7	6.1	6.7	5.5	5.2	5.5	5.0	1.25
04/06/94	6.6	7.0	6.2	6.6	6.7	6.2	5.4	5.7	5.3	1.40
04/07/94	6.5	6.8	6.1	6.2	6.8	5.7	5.5	5.8	5.2	1.30
04/08/94	6.6	7.0	5.8	6.7	7.6	5.6	5.8	6.3	5.3	1.30
04/09/94	7.2	7.7	6.7	7.1	7.6	6.7	6.3	6.8	5.7	1.30
04/10/94	7.3	7.9	6.5	7.6	8.1	6.7	7.0	7.4	6.5	1.30
04/11/94	8.1	8.9	7.1	8.3	9.2	7.1	7.0	7.7	6.3	1.30
04/12/94	8.3	8.6	7.6	8.1	9.2	7.4	6.6	7.3	5.7	1.30
04/13/94	7.2	7.5	6.7	7.0	7.2	6.6	5.9	6.4	5.5	1.30
04/14/94	7.0	7.6	6.7	7.2	7.8	6.6	6.2	6.4	6.0	2.15
04/15/94	7.5	8.4	6.7	7.9	8.9	6.7	6.2	6.6	5.6	2.14
04/16/94	8.7	9.5	7.6	9.2	10.0	8.4	7.4	7.9	6.6	1.30
04/17/94	9.8	10.6	8.6	10.4	11.1	9.4	7.9	8.2	0.0	1.30

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
04/18/94	10.3	10.8	9.9	10.3	10.8	9.9	7.3	8.0	6.6	1.30
04/19/94	9.6	10.0	9.1	9.6	10.1	9.1	6.8	7.8	5.9	1.30
04/20/94	8.9	9.1	8.5	8.8	9.5	8.0	6.4	7.4	5.2	1.30
04/21/94	8.2	8.9	7.7	8.1	8.5	7.4	6.6	7.5	5.6	1.30
04/22/94	7.5	8.0	7.1	7.6	8.1	6.5	5.8	6.9	5.4	1.30
04/23/94	6.9	7.3	6.2	7.1	7.8	6.1	6.2	7.4	5.3	1.30
04/24/94	7.6	7.9	7.2	7.8	8.2	7.2	6.5	7.3	6.0	1.30
04/25/94	7.2	7.5	7.0	7.4	7.8	7.0	6.2	6.4	5.7	1.11
04/26/94	7.2	7.7	6.7	7.4	7.8	6.7	5.7	6.4	5.3	1.00
04/27/94	7.2	7.6	6.7	7.4	8.2	6.3	6.0	6.7	5.3	1.00
04/28/94	7.2	7.6	7.0	7.8	8.5	6.7	5.7	6.4	4.9	7.14
04/29/94	7.2	7.6	7.0	7.8	8.8	6.6	5.8	6.7	5.0	19.02
04/30/94	7.0	7.3	6.7	7.7	8.2	7.0	6.5	7.1	5.9	19.78
05/01/94	7.2	7.8	6.6	8.6	9.6	7.4	7.4	8.2	6.7	19.57
05/02/94	7.8	8.3	7.4	9.7	10.5	8.6	7.8	8.2	7.3	19.36
05/03/94	8.1	8.5	7.6	10.2	11.1	9.5	7.9	8.8	7.1	19.65
05/04/94	8.1	8.3	7.8	10.1	10.6	9.7	8.0	8.7	7.4	20.00
05/05/94	8.3	8.8	7.8	10.3	11.0	9.4	8.4	9.5	7.5	19.90
05/06/94	8.8	9.5	8.0	11.0	11.8	9.9	8.5	9.2	7.7	16.76
05/07/94	9.4	9.8	9.1	11.1	11.9	10.1	8.6	9.7	7.6	9.73
05/08/94	9.7	10.3	9.2	11.3	12.2	10.3	8.8	9.9	7.5	9.74
05/09/94	10.2	11.3	9.3	11.1	11.9	10.3	8.6	9.9	7.3	6.30
05/10/94	10.7	11.3	10.0	10.7	11.5	10.0	8.2	9.3	7.3	1.18
05/11/94	10.3	11.0	9.6	10.5	11.5	9.5	8.6	10.2	7.1	1.10
05/12/94	10.5	11.3	9.6	11.1	11.8	10.3	9.1	10.0	8.3	4.90
05/13/94	9.4	9.8	9.1	10.6	11.2	10.0	8.4	9.2	7.6	9.68
05/14/94	8.8	9.2	8.5	9.8	10.3	9.2	7.6	8.5	6.8	9.68
05/15/94	8.4	8.7	8.1	9.6	10.3	8.9	8.5	9.1	7.9	15.30
05/16/94	8.9	9.3	8.4	10.3	11.1	9.5	8.0	8.9	7.4	20.01
05/17/94	8.5	9.2	8.0	9.4	10.0	9.0	7.5	8.2	7.2	19.78
05/18/94	8.4	8.9	7.8	9.7	10.6	8.6	7.7	8.6	6.9	20.10
05/19/94	8.9	9.3	8.6	10.1	10.6	9.4	8.2	8.5	7.8	19.76
05/20/94	8.5	9.1	8.0	10.1	10.6	9.8	8.3	8.9	7.8	20.01
05/21/94	8.6	9.0	7.9	10.8	11.6	9.9	8.4	8.9	8.0	20.26

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
05/22/94	8.9	9.3	8.6	11.2	11.9	10.3	8.8	9.3	8.4	20.27
05/23/94	9.3	9.6	8.9	11.9	12.8	10.8	9.6	10.6	8.6	20.22
05/24/94	9.7	10.0	9.4	12.9	13.9	11.8	10.4	11.3	9.6	20.20
05/25/94	10.1	10.5	9.7	13.6	14.7	12.6	11.0	11.8	10.3	20.19
05/26/94	10.3	10.5	10.1	14.1	14.9	13.3	11.4	12.0	10.9	20.17
05/27/94	10.5	11.7	10.0	13.5	14.3	12.7	10.7	11.8	9.5	17.25
05/28/94	11.2	11.6	10.5	11.5	12.6	10.6	8.6	9.4	8.3	6.90
05/29/94	10.3	10.5	9.9	10.3	10.6	9.9	8.6	8.9	8.5	5.50
05/30/94	10.8	11.8	9.8	11.1	12.1	9.9	9.5	11.2	8.3	2.36
05/31/94	11.6	11.9	11.2	11.8	12.5	11.3	10.1	11.0	9.6	1.28
06/01/94	12.0	12.4	11.3	11.8	12.3	11.6	9.6	9.8	9.4	1.30
06/02/94	11.7	12.2	11.1	11.8	12.6	10.9	9.7	11.0	8.7	1.26
06/03/94	12.7	13.2	11.8	13.1	14.4	11.9	11.5	12.4	10.8	1.20
06/04/94	14.2	14.8	13.0	14.6	15.0	14.0	12.0	12.5	11.6	1.20
06/05/94	14.0	14.5	13.5	14.0	14.5	13.6	11.2	11.8	10.7	1.20
06/06/94	13.0	13.5	12.1	13.0	13.7	12.6	11.4	12.0	10.5	1.20
06/07/94	12.4	13.0	11.9	12.4	12.7	11.8	9.9	10.3	9.7	1.20
06/08/94	12.0	12.7	11.6	11.9	12.8	11.1	9.4	9.8	8.9	1.20
06/09/94	12.8	13.9	11.5	12.7	13.3	12.1	9.8	10.5	9.1	1.20
06/10/94	13.5	14.7	12.1	13.6	14.4	12.6	11.0	12.3	9.8	1.20
06/11/94	14.2	15.0	13.1	14.5	15.0	14.0	12.7	13.2	12.3	1.20
06/12/94	15.1	16.2	13.9	15.8	16.5	14.9	13.5	14.0	13.0	1.20
06/13/94	15.2	15.8	14.1	15.5	16.1	14.1	12.7	14.1	10.7	1.20
06/14/94	12.7	14.0	10.9	12.0	14.0	11.0	9.3	10.4	8.9	1.20
06/15/94	11.1	11.6	10.6	11.2	12.2	10.2	9.3	10.3	8.4	1.20
06/16/94	11.4	11.7	11.0	11.3	11.8	10.7	10.0	10.4	9.5	1.20
06/17/94	11.6	12.1	10.9	11.8	13.1	10.4	10.1	11.2	9.0	1.20
06/18/94	12.5	12.7	12.1	12.8	13.7	11.8	11.7	12.7	10.8	1.20
06/19/94	13.7	14.5	12.7	14.2	15.6	12.9	12.8	13.5	12.1	1.20
06/20/94	15.2	16.2	14.0	15.8	16.8	14.8	13.6	14.6	12.8	1.27
06/21/94	16.5	17.5	15.2	17.2	18.1	16.3	15.1	16.2	14.2	1.30
06/22/94	17.4	18.6	16.2	18.3	18.9	17.5	15.6	16.2	15.2	1.30
06/23/94	18.0	19.0	17.0	18.8	19.3	18.0	15.4	16.2	14.4	1.30
06/24/94	18.0	19.0	17.1	18.8	19.1	18.3	16.1	16.5	15.7	1.30

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges[a]
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
06/25/94	17.5	18.3	16.7	18.3	18.7	18.0	15.2	16.1	14.6	1.30
06/26/94	16.3	16.7	15.7	17.0	17.7	15.9	14.0	14.7	13.1	1.30
06/27/94	15.9	16.8	14.8	16.2	16.9	15.1	13.0	13.6	12.1	1.30
06/28/94	16.6	17.8	15.0	17.1	17.8	16.2	14.4	15.3	13.4	1.30
06/29/94	17.4	18.7	15.6	18.6	19.5	17.5	16.1	17.1	15.2	1.30
06/30/94	18.3	19.6	16.7	19.6	20.4	18.7	16.8	17.6	16.1	1.30
07/01/94	18.6	19.8	17.2	20.1	20.8	19.3	17.1	18.0	16.5	1.30
07/02/94	18.5	19.3	17.8	20.1	20.6	19.0	16.9	17.4	15.9	1.30
07/03/94	17.7	18.4	16.9	18.6	19.2	18.1	14.9	15.7	14.2	1.30
07/04/94	17.4	18.6	16.0	18.5	19.1	17.8	14.4	15.1	13.7	1.30
07/05/94	15.8	17.2	15.0	16.6	17.7	15.3	13.8	14.4	12.7	1.30
07/06/94	14.2	14.7	13.0	15.2	15.9	14.7	12.6	13.1	12.3	5.59
07/07/94	12.8	14.1	11.6	16.3	17.0	15.2	13.6	14.5	12.5	13.09
07/08/94	11.4	12.5	10.1	18.3	19.3	16.9	16.1	17.4	14.4	18.35
07/09/94	10.8	11.6	10.0	20.2	21.2	19.2	17.4	18.4	16.5	20.24
07/10/94	10.7	11.5	9.8	20.7	21.7	19.4	18.0	19.1	16.8	20.17
07/11/94	10.4	11.2	9.7	21.1	22.0	20.4	17.7	18.7	16.6	20.16
07/12/94	10.5	11.2	9.7	21.1	22.2	20.2	17.4	18.4	16.2	20.15
07/13/94	10.6	11.6	9.9	21.5	22.8	20.5	17.7	18.9	16.2	20.14
07/14/94	10.9	11.8	10.0	22.0	23.2	21.1	18.3	19.3	16.8	20.12
07/15/94	11.1	12.1	10.3	22.2	23.7	21.4	18.8	19.9	17.4	21.07
07/16/94	10.3	11.1	9.4	23.0	24.5	22.0	19.1	20.1	17.5	22.45
07/17/94	10.0	10.9	9.2	23.4	24.8	22.3	19.6	20.6	18.1	23.45
07/18/94	9.7	10.4	9.2	23.5	24.6	22.8	20.1	20.8	19.1	25.53
07/19/94	9.8	10.5	9.2	23.4	24.9	22.2	19.9	20.6	19.0	25.47
07/20/94	10.2	11.1	9.4	23.8	25.6	22.0	19.8	20.6	18.4	25.38
07/21/94	9.4	11.2	7.4	24.5	26.4	22.9	20.6	21.4	19.3	24.83
07/22/94	7.8	8.6	7.2	25.2	27.0	23.5	21.3	22.1	20.1	25.31
07/23/94	7.9	8.6	7.4	25.5	27.2	24.2	21.7	22.1	21.2	25.22
07/24/94	8.1	8.6	7.5	25.6	26.9	24.5	22.2	22.9	21.3	25.08
07/25/94	8.3	9.0	7.5	26.6	28.5	24.8	23.0	23.7	21.9	24.85
07/26/94	8.4	9.3	7.8	26.8	28.1	25.6	23.0	23.6	22.3	24.61
07/27/94	8.4	9.2	7.8	26.4	28.0	25.0	22.8	23.3	22.0	24.64
07/28/94	8.4	9.1	8.0	26.1	27.7	24.5	23.0	23.6	22.1	24.88

Date	Clearwater River temps. (Cherry Lane)			Clearwater River temps. (Orofino)			Selway River temps. (Selway Falls)			Dworshak Discharges”
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	(Kcfs)
07/29/94	8.7	9.1	8.1	25.8	26.8	24.7	22.8	23.0	22.3	23.15
07/30/94	10.3	11.4	8.9	25.3	26.5	24.4	22.1	22.8	21.8	13.30
07/31/94	13.1	14.9	11.1	25.0	26.5	23.5	21.7	22.3	21.1	5.43
08/01/94	17.7	19.9	14.7	25.8	27.3	24.1	21.3	22.1	20.9	1.30
08/02/94	20.5	21.7	19.3	26.5	28.1	24.8	ND	ND	ND	1.30
08/03/94	20.1	21.2	19.6	26.5	28.2	25.3	ND	ND	ND	1.30
08/04/94	21.2	22.0	20.3	26.4	28.0	25.0	ND	ND	ND	1.30
08/05/94	20.1	21.2	19.0	25.5	26.7	24.5	ND	ND	ND	1.30
08/06/94	19.1	20.4	17.9	24.4	25.8	23.1	ND	ND	ND	1.30
08/07/94	19.0	20.5	17.5	24.1	25.9	22.3	ND	ND	ND	1.30
08/08/94	18.9	20.5	17.8	24.0	25.6	22.6	ND	ND	ND	1.30
08/09/94	18.3	19.6	17.1	23.4	25.2	21.9	ND	ND	ND	1.57
08/10/94	17.7	19.2	16.1	23.1	25.1	21.1	ND	ND	ND	1.30
08/11/94	18.3	19.9	17.1	23.2	25.3	21.5	ND	ND	ND	1.30
08/12/94	18.6	20.5	17.1	23.5	25.6	21.7	ND	ND	ND	1.31
08/13/94	18.9	20.7	17.4	24.1	26.5	21.9	ND	ND	ND	1.30
08/14/94	19.1	21.0	17.7	24.7	27.0	22.8	ND	ND	ND	1.31
08/15/94	19.1	20.8	17.7	24.5	26.2	23.2	ND	ND	ND	1.30
08/16/94	18.2	19.8	16.8	23.2	24.8	21.6	ND	ND	ND	1.30
08/17/94	17.9	19.5	16.3	22.8	24.7	20.9	ND	ND	ND	1.30
08/18/94	17.8	19.5	16.2	22.7	25.0	20.5	ND	ND	ND	1.30
08/19/94	17.8	19.5	16.2	22.6	24.2	20.8	ND	ND	ND	1.30
08/20/94	17.6	19.2	16.2	22.5	24.0	21.0	ND	ND	ND	1.30
08/21/94	17.5	19.1	16.2	22.3	23.8	20.8	ND	ND	ND	1.30
08/22/94	16.9	17.9	16.2	21.5	22.5	20.7	ND	ND	ND	1.30
08/23/94	16.6	18.3	15.0	21.0	22.5	19.5	ND	ND	ND	1.30
08/24/94	17.0	18.7	15.5	21.3	23.0	19.5	ND	ND	ND	1.30
08/25/94	16.8	18.4	15.3	21.2	22.9	19.3	ND	ND	ND	1.30
08/26/94	16.7	18.3	15.3	21.1	22.5	19.5	ND	ND	ND	1.30
08/27/94	16.7	18.3	15.1	21.3	22.9	19.5	ND	ND	ND	1.30
08/28/94	16.9	18.7	15.5	21.1	22.3	19.9	ND	ND	ND	1.30
08/29/94	16.9	18.3	15.9	21.1	22.0	20.1	ND	ND	ND	1.30
08/30/94	16.4	18.0	15.1	20.8	22.5	19.1	ND	ND	ND	1.30
08/31/94	16.6	18.1	15.2	21.0	22.6	19.3	ND	ND	ND	1.30

Date	Clearwater River temps. (Cherry Lane) Ave.	Max.	Min.	Clearwater River temps. (Orofino) Ave.	Max.	Min.	Selway River temps. (Selway Falls) Ave.	Max.	Min.	Dworshak Discharges[a] (Kcfs)
09/01/94	16.7	18.1	15.6	21.1	22.3	19.9	ND	ND	ND	1.30
09/02/94	16.7	18.0	15.8	21.1	22.0	20.2	ND	ND	ND	1.30
09/03/94	15.8	16.2	15.3	20.0	20.7	19.5	ND	ND	ND	1.30
09/04/94	15.5	16.9	14.4	19.5	20.4	18.9	ND	ND	ND	1.30
09/05/94	15.4	17.1	13.6	19.0	20.8	17.4	ND	ND	ND	1.30
09/06/94	15.8	17.6	14.4	19.0	21.0	17.2	ND	ND	ND	1.30
09/07/94	16.4	18.3	15.1	19.5	21.4	17.6	ND	ND	ND	1.30
09/08/94	16.2	17.5	15.1	19.7	21.3	18.1	ND	ND	ND	1.30
09/09/94	15.1	15.9	14.0	18.5	19.6	17.7	ND	ND	ND	1.30
09/10/94	14.1	15.6	12.9	17.1	18.2	16.0	ND	ND	ND	1.30
09/11/94	14.5	16.2	13.1	16.9	18.3	15.7	ND	ND	ND	1.30
09/12/94	14.4	15.9	13.1	16.7	18.0	15.3	ND	ND	ND	1.30
09/13/94	13.8	14.8	13.3	16.5	17.2	15.6	ND	ND	ND	1.30
09/14/94	13.5	14.5	12.4	16.3	16.8	15.4	ND	ND	ND	1.30
09/15/94	14.5	16.0	13.0	16.9	18.3	15.7	ND	ND	ND	1.30
09/16/94	15.0	16.5	13.7	17.3	19.1	15.7	ND	ND	ND	1.30
09/17/94	15.1	16.8	13.4	18.0	19.5	16.3	ND	ND	ND	1.31
09/18/94	15.4	17.1	13.9	18.4	19.9	16.9	ND	ND	ND	1.30
09/19/94	15.5	16.9	14.3	18.6	20.2	17.1	ND	ND	ND	1.31
09/20/94	15.5	17.1	14.3	18.8	20.2	17.6	ND	ND	ND	1.30
09/21/94	15.4	16.9	14.3	18.7	19.9	17.7	ND	ND	ND	1.31
09/22/94	14.9	16.3	13.5	18.2	19.8	16.8	ND	ND	ND	1.31
09/23/94	14.8	16.5	13.2	17.9	19.5	16.5	ND	ND	ND	1.30
09/24/94	14.8	16.5	13.5	17.6	19.2	16.4	ND	ND	ND	1.30
09/25/94	14.7	16.2	13.6	17.3	19.0	16.2	ND	ND	ND	1.30
09/26/94	14.6	16.2	13.5	17.2	19.0	16.0	ND	ND	ND	1.30
09/27/94	14.5	15.9	13.4	17.1	19.0	15.9	ND	ND	ND	1.31
09/28/94	14.3	15.9	13.2	16.7	18.3	15.6	ND	ND	ND	1.30
09/29/94	13.9	14.2	13.6	16.0	16.3	15.6	ND	ND	ND	1.30
09/30/94	14.4	15.9	13.3	16.6	18.5	15.4	ND	ND	ND	1.30

[a] Dworshak Dam discharge data obtained from the U.S. Army Corps of Engineers.